This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

AS
0300

Per27

HARVARD UNIVERSITY

LIBRARY OF THE

DEPARTMENT OF MINING
AND METALLURGY

THE

SCHOOL OF MINES QUARTERLY

A JOURNAL OF APPLIED SCIENCE

VOL. XXXIV

NOVEMBER, 1912, TO JULY, 1913

COLUMBIA UNIVERSITY
NEW YORK CITY

1913

1996-17

BOUND MAY 26 1914

BOARD OF EDITORS

W. CAMPBELL, Assoc. Prof. of Metallurgy.
JAMES K. FINCH, Instructor in Civil Engineering.
EDWARD K. JUDD, Instructor in Mining.
JAMES F. KEMP, Professor of Geology.
C. E. LUCKE, Prof. of Mech. Engineering.
R. E. MAYER, Assoc. Prof. of Drawing.
A. J. MOSES, Professor of Mineralogy.
ROBERT PEELE, Professor of Mining.
W. I. SLICHTER, Prof. Elect. Engineering.
H. C. SHERMAN, Prof. Organic Analysis.
ARTHUR L. WALKER, Prof. of Metallurgy.
ELWYN WALLER, Analytical Chemist.

MANAGING EDITOR—EDWARD K. JUDD

THE

SCHOOL OF MINES QUARTERLY

INDEX VOL. XXXIV.

November, 1911, to July, 1913.

All Abstracts are printed in Italics, and appear only under the heading Analytical Chemistry.

ADAMS, MASON T. A System of Mine Accounts 137
Alumni Association, Annual Meeting:
of April 26, 1912 64
of April 24, 1913 406
Alumni Notes 80, 182, 292, 417
Alumni, Opinions of concerning the Quarterly 70
ANALYTICAL CHEMISTRY, ABSTRACTS. By Elwyn Waller 44, 396
Acetylene, Test for 56
Acidimetric Solutions, Standardizing 44
Alkalies in Rocks 399
Alkaline Bicarbonate in presence of Carbonate 46
Ammonia — Nesslerizing 44
Antimony in Enamels 55
Antimony in White Metals 48
Carbon Dioxide 44
Chlorous Acid 47
Copper-Arsenic Group, Separation 47
Copper in Steel 51
Copper — Sulfocyanate-Permanganate Method 400
Copper in White Metal 397
Cyanogen and Hydrogen Cyanide 47
Dust in Air 56
Ferro-Boron 52
Ferro-Tungsten 52
Ferrous Iron — Qualitative 51
Fluorine Determination 50
Fluorspar 50
Glucinum, Separation from Aluminum 400
Gold, Silver, and Platinum 50
Hypochlorites 396
Iodides — Direct Titration 54

Iodine in Sea-weed, etc. 54
Iron in Lead Oxides 48
Kaolin, Effecting Solution of 46
Lead — Molybdate Titration 48
Lime in Presence of Magnesia 50
Linseed Oil 55
Magnesia — Thermochemical method 45
Manganese — Electrolytically 48
Manganese in Ores, etc. 398
Marking Porcelain Crucibles 44
Mercury, Purification of 49
Molybdenum — Electrolytically 48
Nickel in Alloys 48
Nitrates in Waters 55, 400
Nitric Acid in presence of Nitrous 45
Perchlorate Determination 46
Permanganate, Standardizing 396
Petroleum in Paint Oils, etc. 55
Phospho Molybdate from Silico Molybdate, Separating 44
Platinum in Ores and Bullion 49
Potassium Iodate 46
Prussian Blue in Silks 401
Pyrites, Sulfur in 398
Rare Earths — Separation 53
Sodium Peroxide 396
Sulfates in Water 55
Sulphur in Insoluble Sulphides 44
Sulfuric Acid, Purifying 396
Thorium in Monazite, etc. 53
Thorium — Volumetric 52
Tin in Bronze 400
Tin — Volumetric 39, 399
Titanium 397
Tungstates and Molybdates 46
Vanadium in Irons and Steels 51
Vanadium, New Method 54
Yttrium Separation 53
Zinc and Nickel, Separation of 399
Zinc — Separation of Iron from 49
Zinc Titration by Ferrocyanide 398
Zirconia, Separation of from Iron and Alumina 53
Anthracite Mining, Electricity in. By W. P. Jennings 151
Austin, Nev., Ores from. By H. B. Taylor 32
Book Reviews 73, 171, 278, 402
Building Stones and Clay-Products. By Heinrich Ries..... 404
Business of Mining. By A. J. Hoskin 73
Cement Testing, Manual of. By W. A. Richards..... 278
Chemical Arithmetic and Calculation of Furnace Charges. By R. Chauvenet 284

Chemical Theory and Calculations. By Wilson and Heilbron..... 403
Chemistry, General and Industrial. By Molinari 278
Coal, its Composition, Analysis, Utilization and Valuation. By E. E. Somermeier 403
De Re Metallica. By G. Agricola. (Translation by Hoover)..... 280
Inorganic Chemistry, Text Book of. By A. Senter..... 171
Iron Ores of Missouri. By G. W. Crane..... 279
Mechanical Drawing. By O. M. Graves 405
Metallography of Iron and Steel. By Albert Sauveur..... 75
Mine Accounting, American. By W. H. Charlton 172
Mine Structures, Design of. By M. S. Ketchum..... 171
Minerals, Introduction to the Study of. By Austin F. Rogers..... 76
Physics, Essentials of, for College Students. By D. W. Hering.... 78
Physics, Text Book of. By A. W. Duff..... 79
Physics, Text Book of. By Hurst and Lattey 405
Physical Chemistry, Problems in. By E. B. R. Prideaux..... 74
Practical Field Geology. By Farrell and Moses 78
Qualitative Analysis, Notes on. By Byers and Knight..... 77
Refractories and Furnaces. By E. T. Harvard..... 173
Transmission Line Formulas. By H. B. Dwight..... 402
Ventilation of Mines. By R. A. S. Redmayne..... 73
Bore-Hole Surveying, Notes on. By Sidney L. Wise..... 149
BRETTELL, CLINTON. Economics of Motor Trucking.....241, 359
BROWNE, C. A. By-Products of Sugar Manufacture, and Methods for their Utilization 370
Manufacture of Raw Sugar in the Philippine and Hawaiian Islands.. 119
By-Products of Sugar Manufacture, and Methods for their Utilization. By C. A. Browne 370
CANFIELD, F. A. Mosesite 276
Chuichos Coal Mine, Peru. By Lester W. Strauss 24
Conservation. By James Douglas 335
Dam, Hollow, of the Buttress Type. By J. K. Finch and W. F. Thoman. 219
Diamond Drilling, Notes on. By A. E. Hall 40
DOUGLAS, JAMES. Conservation 335
Editors of the Quarterly, Meeting of..... 68
Electricity in Anthracite Mining. By W. P. Jennings 151
Engineering Library Efficiency. By W. D. Johnston 26
FINCH, J. K. and THOMAN, W. F. Hollow Dam of the Buttress Type.. 219
FINLAY, JAMES R. Principles of Mine Valuation 87
Fireproof Construction for New York. By Harold Perrine..... 259
FLASHMAN, HORACE W. Power-Plant Economics 1, 96
HALL, A. E. Notes on Diamond Drilling 40
Stoping Drills at Sudbury 383
HOWE, HENRY MARION, Sketch of 301
Hydraulic Mining, Principles of. By H. L. Mead..... 187
Hyperbolic Functions, and their Application to Electrical Engineering. By J. H. Morecroft 202
JENNINGS, WILLIAM P. Electricity in Anthracite Mining 151
JOHNSTON, W. D. Engineering Library Efficiency 26

MEAD, H. L. Principles of Hydraulic Mining 187
Microscope, Polarizing, for the Study of Minerals in Crushed Fragments. By A. J. Moses 305
Mine Accounts, System of. By M. T. Adams..... 137
Mine Valuation, Principles of. By J. R. Finlay 87
Minerals, Polarizing Microscope for the Study of. By A. J. Moses.... 305
MORECROFT, J. H. Hyperbolic Functions and their Application to Electrical Engineering 202
MOSES, A. J. Polarizing Microscope for the Study of Minerals in Crushed Fragments 305
Mosesite. By F. A. Canfield 276
Motor Trucking, Economics of. By Clinton Brettell 241, 359
Obituary Notes 84, 186, 298
Ores from Austin, Nev. By H. B. Taylor 32
PAZOS Y SACIO, V. Smelting in Shaft Furnaces at Great Altitudes..... 344
PERRINE, HAROLD. Tests of Fireproof Construction for New York..... 259
Power-Plant Economics. By Horace W. Flashman 1, 96
Principles of Mine Valuation. By J. R. Finlay 87
Pyrrhotite, Relation of, to Chalcopyrite and other Sulphides. By A. P. Thompson 385
Quarterly, The Future of 67
Reinforced Concrete Studies — Hollow Dam of the Buttress Type. By J. K. Finch and W. F. Thoman 219
Smelting in Shaft Furnaces at Great Altitudes. By V. Pazos y Sacio.. 344
Stoping Drills at Sudbury. By A. E. Hall 383
STRAUSS, LESTER W. Chuichos Coal Mine, Peru 24
Sugar Manufacture, By-Products of, and Methods for their Utilization. By C. A. Browne 370
Sugar, Manufacture of in the Philippine and Hawaiian Islands. By C. A. Browne 119
System of Mine Accounts. By M. T. Adams 137
TAYLOR, H. B. Study of Ores from Austin, Nev. 32
THOMAN, W. F. and FINCH, J. K. Hollow Dam of the Buttress Type.. 219
THOMPSON, A. P. Relation of Pyrrhotite to Chalcopyrite and other Sulphides 385
UNIVERSITY NEWS 57, 174, 285, 410
Admission of Students with Advanced Standing 174
Alumni Notes 80, 182, 292, 417
Annual Reports 155
Camp Columbia 57
Chemistry 158
Civil Engineering 161, 291
Civil Engineering Society 177, 286
Dean's Report 157
Egleston Bust 414
Electrical Engineering 164, 286
Electrical Engineering Society 287
Faculty Notes 180, 291, 416
Geological Journal Club 178, 289

Geology 59, 165, 178, 285
Gift to School of Mines 178
Highway Engineering 175, 285
Honor System 179
Mechanical Engineering 166
Mechanical Engineering Society 177, 286, 414
Metallurgy 60, 167, 178, 285
Mineralogy 169
Mining 62, 170, 174, 286, 413
Phi Lambda Upsilon 176, 286
President's Report 155
Semi-Centennial Committee 287
Senior Mining Society 176, 414
Sigma Xi 176, 289, 414
Summer Activities 176, 414
Tau Beta Pi 176. 414
The Three-Year Course 410
Y. M. C. A. 287
WALLER, E. Abstracts, Analytical Chemistry 44, 396
WISE, SIDNEY L. Notes on Bore-Hole Surveying 149

VOL. XXXIV. No. 1. NOVEMBER, 1912

THE

SCHOOL OF MINES QUARTERLY.

A JOURNAL OF APPLIED SCIENCE.

CONTENTS

	PAGE
POWER-PLANT ECONOMICS — I. By *Horace W. Flashman*....	1
CHUICHOS COAL MINE, PERU. By *Lester W. Strauss*.....	24
ENGINEERING LIBRARY EFFICIENCY. By *W. Dawson Johnston*.	26
STUDY OF ORES FROM AUSTIN, NEV. By *H. B. Taylor*.....	32
NOTES ON DIAMOND DRILLING. By *Albert E. Hall*	40
ABSTRACTS — ANALYTICAL CHEMISTRY. By *E. Waller*.....	44
SUMMER ACTIVITIES	57
ANNUAL MEETING OF ALUMNI ASSOCIATION	64
FUTURE OF THE QUARTERLY	67
BOOK REVIEWS	73
ALUMNI NOTES	80

COLUMBIA UNIVERSITY
NEW YORK CITY

Registered at the New York Post Office as Second Class Matter

TWO DOLLARS PER YEAR. FIFTY CENTS PER NUMBER.
All Remittances should be made payable to order of "The School of Mines Quarterly"

MOORE PATENT UPHELD BY HIGHEST COURT

In the case of *The Moore Filter Company* vs. *Tonopah-Belmont Development Company* (defended by the Butters Company), the U. S. Circuit Court of Appeals has just handed down a sweeping opinion sustaining the validity of The Moore Process Patent (U. S. 764,486) for filtering slimes, holding the stationary or "Butters" type an infringement, and directing judgment against the defendant for an injunction and an accounting of profits.

FROM THIS DECISION THERE IS NO APPEAL

This patent, now judicially declared valid, is for our basic and fundamental process of filtering slimes by submergence of the filtering medium, drawing away the solution through the filtering medium, and impoverishing or washing the cake by cleansing operation; and anticipates and renders infringements all the various types of filtering apparatus using the process, whether such types be movable, stationary (as in the present litigation) pressure, drum or revoluble.

The Moore Filter Company

New York, U. S. A.

THE
SCHOOL OF MINES
QUARTERLY

VOL. XXXIX. NOVEMBER, 1912. No. 1.

POWER-PLANT ECONOMICS.— I.

BY HORACE W. FLASHMAN.*

I.— THE FIELD OF ECONOMICS. CONSERVATION OF HEAT.

The successful commercial operation of a generating station will depend on: First, the skilful selection of (a) main engines and generators, (b) boilers, (c) auxiliary apparatus. Second, the proper purchase and preparation of (d) water, (e) coal, (f) supplies. Third, the development of an operating schedule appropriate to (g) the working apparatus, (h) the operating personnel.

Other important considerations, such as location of site, proximity to load center, selling price, etc., do not fall within the scope of the present discussion, as they are either unalterable, or do not affect the cost of generation. The concern of this discussion is particularly with item (g), the development of an operating schedule appropriate to the working apparatus; to ascertain if there are not certain general laws controlling the operation of many machines in parallel for maximum economy when economy curves for individual machines are given. These laws, once determined, may be applied to item (a), the selection of main engines and generators, and the suitability of different machines for a particular service thus determined and compared.

In Chapter II a method is developed by which an equation can be found (in general), which will represent closely the water rate curve of an engine. From this the total water used over a given period of load can be estimated. Equations are derived in illus-

* Sydney, N. S. W. A thesis, of which the full title was "The Economical Use of Power-Plant Units having Known Characteristic Curves," presented for the degree of Master of Arts in Columbia University, April, 1910.

tration for several different types of engine. In Chapter III, specific operating problems, e.g., the switching in of an additional machine, the division of load between units, etc., are considered and applications are made to particular cases.

I will first state some results obtained in actual practice for the different economies commonly attempted, noting the commercial limitations of each. This will be followed by a thermodynamic analysis of the same problems, showing what improvement might have been expected. The latter is not always a reliable guide, since it can take no account of the cost of the apparatus and power required to effect the change.

H. G. Stott gives the following table, analyzing the average losses in the conversion of one pound of coal into electricity:

		Input		Losses	
		B.T.U.	Percent.	B.T.U.	Percent.
1.	B.t.u. per lb. coal supplied	14,150	100.		
2.	Loss in ashes			340	2.4
3.	Loss in stack			3,212	22.7
4.	Loss in boiler radiation, and leakage			1,131	8.0
5.	Returned by feed water heater	441	3.1		
6.	Returned by economizer	960	6.8		
7.	Loss in pipe radiation			28	0.2
8.	Delivered to circulator			223	1.6
9.	Delivered to feed pump			203	1.4
10.	Loss in leakage and H.P. drips			152	1.1
11.	Delivered to small auxiliaries			51	0.4
12.	Heating			31	0.2
13.	Loss in engine friction			111	0.8
14.	Electrical losses			36	0.3
15.	Engine radiation losses			28	0.2
16.	Rejected to condenser			8,524	60.1
17.	To house auxiliaries			29	0.2
	Totals	15,551	109.9	14,099	99.6
	Deduct losses	14,099	99.6		
	Delivered to bus bars	1,452	10.3		

Thus 60 percent. of the total heat is rejected to the condenser, 22.7 percent. is required to maintain the draft. Most of this work is unobtainable. It is chargeable, not to the inefficiency of the mechanism, but to the inefficiency of the system. Only 10.3 percent. appears as useful available energy.

Auxiliaries.— Steam driven auxiliaries are more satisfactory than electric. In steam pumps the consumption is high — 60 to 100 lb. per b.h.p.-hr.—but by exhausting into a feed-water heater, the latent heat is regained. With electric drive the power is taken from the

thermally inefficient main engine; only one-third or one-fourth as much steam will then be required, but the latent heat will be lost. There is also the very common feeling that steam is more dependable.

Feed Heaters.— Feed-water heaters and economizers serve the same purpose, but it is not undesirable to install both. Feed-water heaters, either open or closed, may raise the temperature from 100° in the hotwell to 150° F., while the economizer will then deliver it at 250° to 275° F. If the feed-water heater were omitted, the temperature would not be over 200° F.

Tests of plants (Barrus) show an increased evaporation of 7 to 10.5 percent. with economizers, and other tests (Wm. Roney) show a saving in coal of 10 to 17 percent. There is a saving of roughly 0.0909 percent. per 1° F. that the feed temperature is raised. Hence the high efficiency of the "Contraflo" condenser, made by Messrs. Richardson, Westgarth & Co., Hartlepool, England. If some feed-water heating apparatus will raise the temperature 110° F., it is profitable to install it when 10 percent. of the total coal bill is greater than the total increased annual charge, due to its installation. When the draught is already poor, the economizer is, of course, inadmissible.

Non-Condensing Operation.— The 60 percent. rejected to the condenser would be very much greater if the engine ran non-condensing. Due to condensers, the saving in steam is from 20 to 25 percent. Great care must be taken that the auxiliaries do not offset this saving.

Steam to Auxiliaries.— For a 26-in. vacuum, the steam consumption of the auxiliaries, including the feed pump, will average 10 percent., with a range of 6 to 15 percent. Exhausting into a feed-water heater, less than 10 percent. of the heat is used in the auxiliaries. In some tests of larger units, as much as 40 percent. of the amount of steam used in the main engines has been taken by the auxiliaries, mainly the circulating pump.

In a test of a 500-kw. set, in which the auxiliaries took 12.9 percent. as much steam as the turbine, the division was as follows:

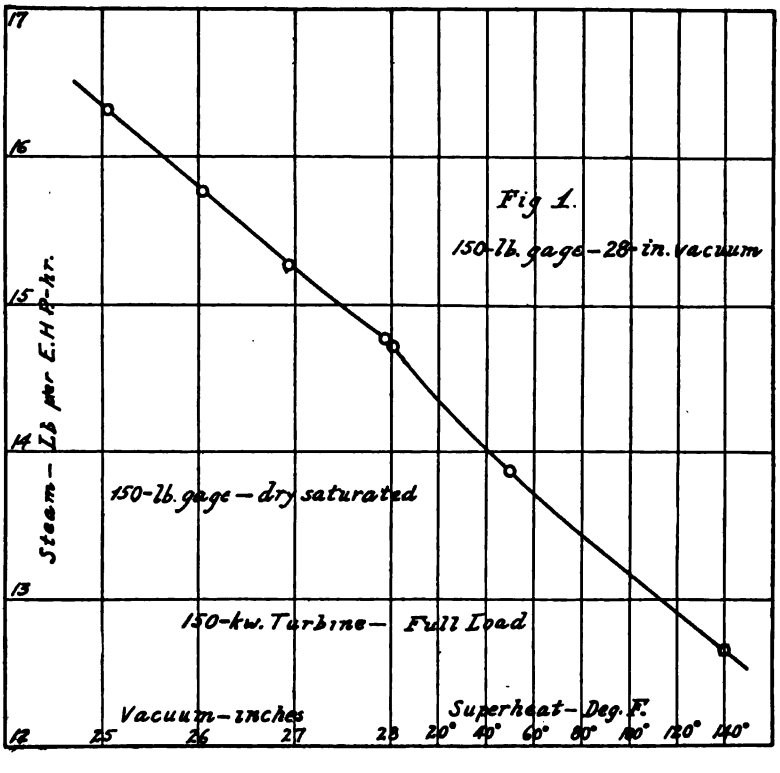
Accumulator pump	1.25%	Boiler feed pump	3.4%
Dry air pump	1.75%	Circulating pump	6.5%

In this case the boiler feed pump acted as a wet vacuum pump.

Power taken by the auxiliaries in a 5000-kw. turbine plant of the Edison Illuminating Company of Boston, was as follows:

Kilowatts on turbine	2713	3410	4758.
Vacuum, in. of mercury	28.4	28.7	28.6
Barometer, in. of mercury	29.53	29.95	29.96
I.H.P. of boiler feed pump	13.9	23.7	27.4
" " circulating pump	69.1	69.1	69.1
" " dry vacuum pump	24.3	23.2	23.8
" " step bearing pump	6.4	5.8	5.6
Electric h.p. of wet vacuum pump	8.6	9.2	9.8
Total power of auxiliaries	122.3	131.	135.7
Percent power for auxiliaries	3.4	2.9	2.1
Percent water used by auxiliaries	8.4	7.4	5.7

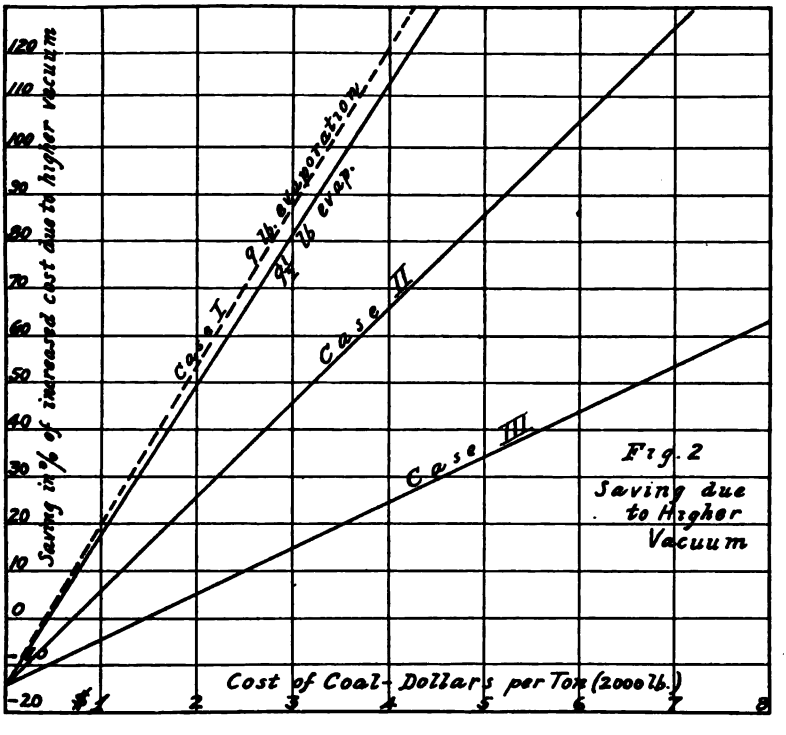
Saving due to High Vacuum.— The saving due to vacuum and superheat has been very carefully examined by the various turbine builders, and curves (Fig. 1) show the effect on the Westinghouse-



Parsons type. From many tests it is claimed that 100° F. superheat reduces the steam consumption by 10 percent., and that 1 in.

higher vacuum, between 25 and 28 in., reduces it by 3.4 to 4 percent., depending somewhat on the load.

The curve (Fig. 2) is based on a plant of two 1000-kw. units. By raising the vacuum from 26 to 28 in., a saving of 3.5, 2.6 and 1.3



tons per day, respectively, is effected. The cost of higher-vacuum apparatus will be not more than $2 per kilowatt, or $4000. Deducting interest and depreciation on this investment from the several fuel savings, an interest rate is reached representing a net saving of 115 percent., 27 percent., and -3 percent. on the increased investment. The increased power will reduce these figures by 1 to 5 percent. If we add the price of water saved, the percentage will be increased. These estimates, although largely tentative, point to high vacuum as an excellent investment where high plant economy is desired.

RELATIVE ECONOMY OF HIGH VACUUM:

	I.	II.	III.
Condition of operation	Good coal, continuous service.	Med. coal, continuous service.	Poor coal, day service.
Capacity of plant, kw.	2000	2000	2000
Daily run, hr.	24	24	10
Yearly run, days	365	300	300
Average load, kw.	1500	1000	1000
Price coal, per 2000 lb.	$4.00	$2.00	$1.00
Evaporation, actual lb.	9.5	8.	7.
Average economy, lb. water per kw.-hr.	23	22	22.
Raise vacuum, in.	26 to 28	26 to 28	26 to 28
Water saved per day, lb.	66,240	42,240	17,600
Coal saved per day, tons	3.49	2.64	1.26
Gross saving per year	$5,095	$1,584	$ 378
Extra cost of condenser	4,000	4,000	4,000
Interest, 5 percent., Depreciation, 7½ percent.	500	500	500
Net saving per year	$4,595	$1,084	−$122

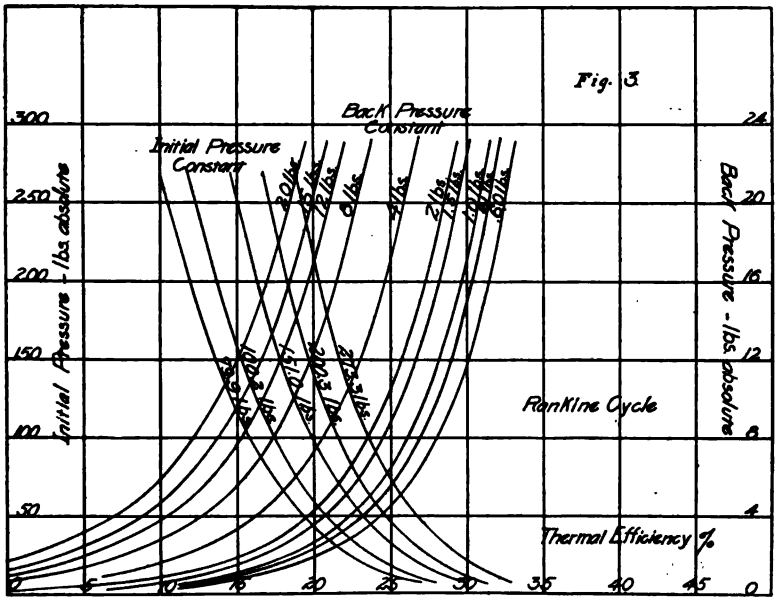
The curve (Fig. 2) illustrates this, and covers in addition a considerable range of fuel values. With cheap coal there is evidently a point where high vacuum ceases to be a source of economy. Under the conditions assumed, this occurs with coal at 42c., 62c., and $1.36 per ton respectively. On the other hand, with coal at $3.55 and $5.20, respectively, in cases I and II, the annual saving will equal the cost of the improvement in one year.

Saving due to Superheat.— A similar analysis can be applied to the use of superheat; 100° F. is usually specified in American turbine plants, and this can be obtained by an apparatus mounted within the boiler setting, where it intercepts the hot gases. A 10-percent. increase in economy is effected and the installation cost is 25 percent. less than that necessary to secure an extra 2 in. of vacuum. Care must always be taken to flood such a superheater when starting up. Superheating the steam serves to delay the dew point, thus minimizing the loss by condensation and fluid friction. Superheating at constant pressure is thermodynamically good. It is not wise to generate at a high pressure and superheat by throttling. Superheating at constant energy, where it tends to increase the entropy, is thermodynamically unsound, as it increases the proportion of unavailable work.

THE VALUE OF HIGH VACUUM AND SUPERHEAT.

Rankine Cycle.—The gain in thermal efficiency obtained by a

change in any of the three variables, pressure, temperature, vacuum, can be best understood by first deciding on certain combinations of processes as standard cycles, and by then plotting a set of efficiency curves for each. One of the most widely applicable is that of Rankine, recommended by the British Institution of Civil Engineers and the American Society of Mechanical Engineers as the standard, which assumes dry saturated steam, adiabatic expansion, and exhaust at constant back-pressure. Curves for this cycle are shown in Fig. 3. One set shows contours of constant back-pressure, il-

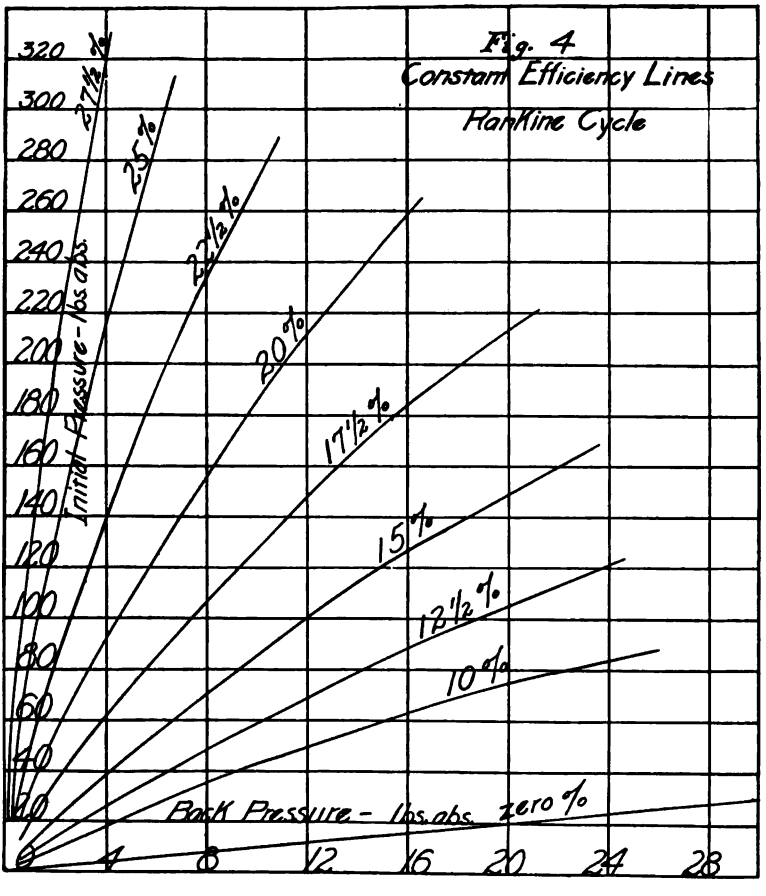


lustrating the increase of thermal efficiency with increase of initial pressure. A second set are contours of constant boiler pressure and bring out the increase of efficiency with decrease of back pressure. Combining these two sets, a third set has been drawn giving contours of constant efficiency from which very interesting conclusions can be drawn, (Figs. 4 and 5).

Limiting Efficiency.— From all the curves it is evident that, above a certain pressure, further increase in boiler pressure produces only a relatively small increase in thermal efficiency. This limit occurs

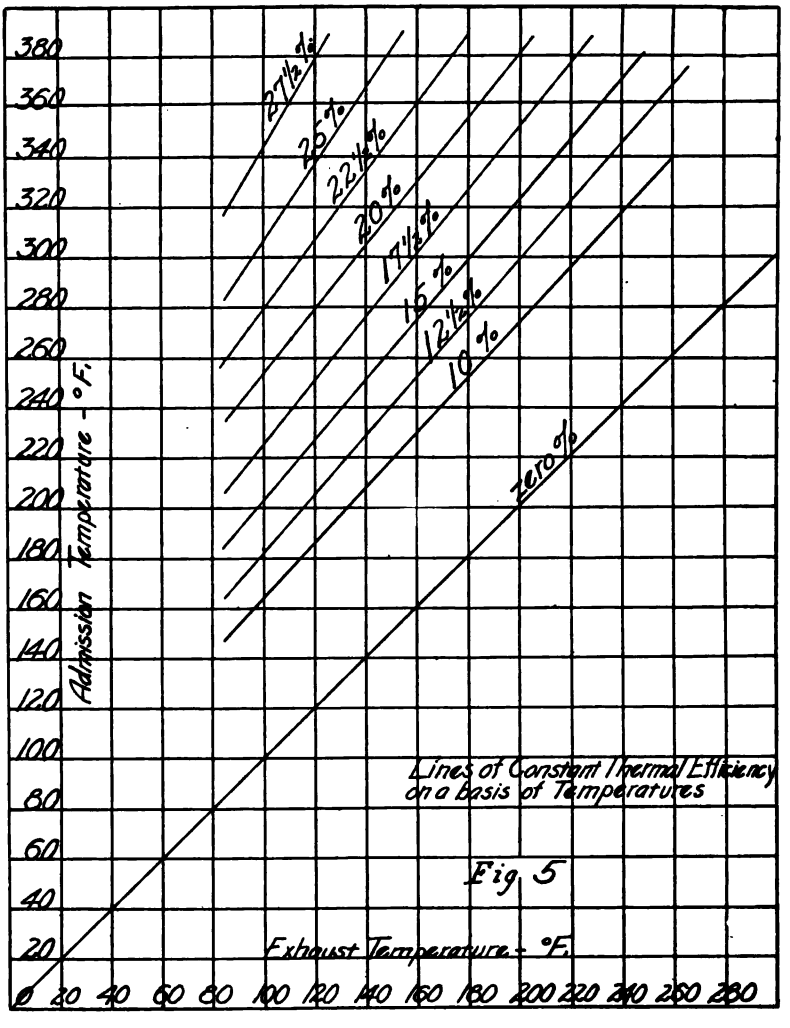
at about 170 lb. per sq. in. It would appear that with the best vacuum and with the highest pressure obtainable, the efficiency could not exceed about 35 percent., using saturated steam. Each curve tends to become asymptotic to some vertical axis of constant efficiency appropriate to its back-pressure.

The rate of increase in efficiency is a function of the back pres-



sure. For an increase in boiler pressure from 75 lb. to 275 lb., with a back-pressure of 1 lb. the increase is 7 percent., and with a back-pressure of 20 lb., the increase is 9 percent. Expressed in terms of the efficiency at the lower pressure, the increase is respectively 27.4 percent., for 1 lb., and 90.0 percent. for 20 lb. back-pressure.

Vacuum Variations.— Vacuum variations have far greater effects than pressure changes. This is clear from the form of the efficiency expression: Work done ÷ Heat supplied. In a vacuum



change, only the numerator is affected. In a pressure change both numerator and denominator are increased or decreased together.

The rate of increase in efficiency increases rapidly with decrease in back-pressure. It is also a function of the boiler pressure, being

greatest at the lower pressures. At 151 lb. boiler pressure (absolute) 1 percent. increase in efficiency corresponds to a 3-lb. drop from 20 lb.; to a 2-lb. drop from 12 lb.; to a 1.25-lb. drop from 6 lb.; to a 0.50-lb. drop from 2 lb.; and to a 0.30-lb. drop from 1 lb.

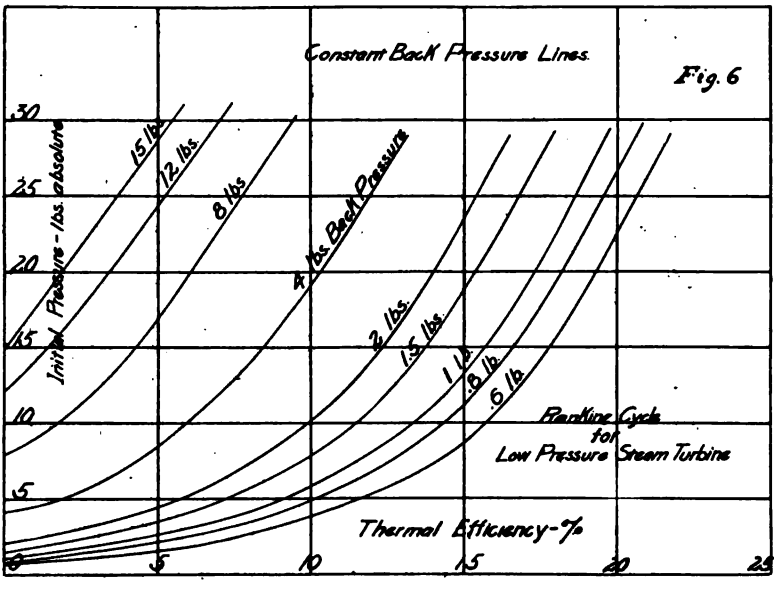
Between 20 lb. back-pressure and 6 lb. back-pressure the efficiency increases thus:

For 273.3-lb. boiler pressure, from 19.2 percent. to 32.8 percent.—or 13.6 percent.

For 79.9-lb. boiler pressure, from 10.4 percent. to 27.0 percent.—or 16.6 percent.

Expressed in terms of the efficiency at the higher pressure, this is 71 percent., and 16 percent. respectively.

Low Pressure Steam Turbine.—The portion of the initial pressure-efficiency diagram for pressures up to 30 lb. has been enlarged (Fig. 6). This demonstrates plainly the greater dependence



of efficiency on vacuum than on initial pressure. For a similar increase in initial pressure (of 15 lb.) the thermal efficiency is increased 5 percent. with a 15-lb. back-pressure, and 18 percent. with a 6-lb. back-pressure.

This diagram covers the practical case of the low-pressure steam turbine. For the variation in nozzle pressure obtaining in the 59th Street station, the thermal efficiency of the low-pressure turbine may vary from 13 to 18½ percent. Similarly, with steam initially at 190 lb. per sq. in., and with a back-pressure varying from 8 to 21 lb. on maximum load, the efficiency of the engine may vary between 21.25 and 16 percent.

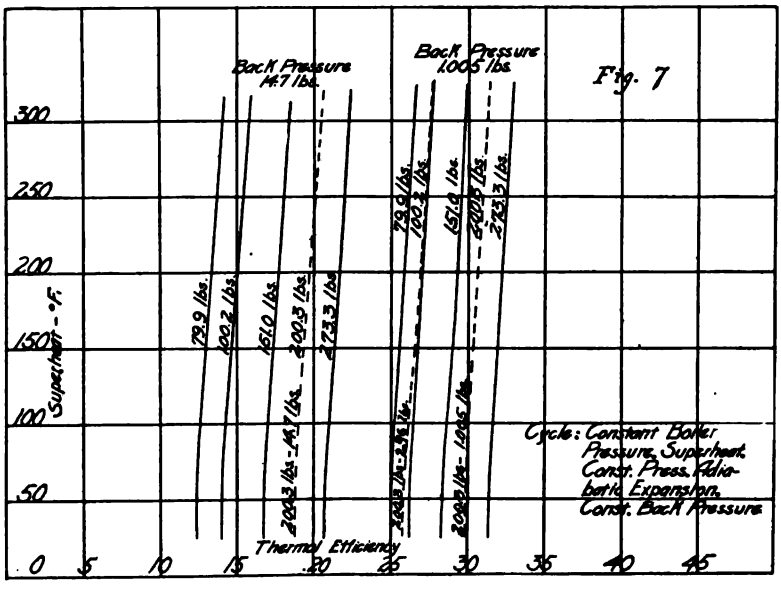
Sensitiveness of Turbine.— The curves of thermal efficiency for the Rankine cycle, covering the range of the low-pressure steam turbine, while illustrating the marked advantages of high vacuum, show also the marked sensitiveness of the efficiency to slight variations in either initial- or back-pressure. With a vacuum of 28.8 in. a drop in initial pressure from 20 lb. absolute to 14 lb. will decrease the efficiency from 19.5 to 17.5 percent., whereas a drop in vacuum of only 0.8 in., from 28.8 to 28 in., decreases the efficiency from 18 to 15.75 percent., i.e. 2.25 percent. Thus the high-vacuum steam turbine calls for greater vigilance and a higher grade of auxiliary than the reciprocating engine, but it offers in return considerable scope for economy.

Cycle with Superheat.— Another cycle of considerable practical application is that in which the steam is superheated at constant pressure, expanded adiabatically and exhausted at constant back-pressure. Curves for this cycle are plotted (Fig. 7) up to 300° F. for both atmospheric exhaust and for 28 in. vacuum (1.005 lb. abs.), for the same five pressures as before. This diagram is valuable in that it illustrates the whole problem within itself.

By the large displacement of the set at 1.005 lb. back-pressure, compared with that at 14.7 lb., the increase in efficiency, due to high vacuum, is illustrated. Each set illustrates the increase in efficiency, with increase in boiler pressure, showing also that this effect is greater with a *poor* vacuum.

Superheating increases the thermal efficiency only very slightly (about 1½ percent. for 300° F.); the improvement is practically constant under all conditions of initial- and back-pressure. Three lines are shown dotted on this diagram. These illustrate the effect of combined vacuum and superheat when the boiler pressure remains constant, 200.3 lb. absolute.

Contours of Constant Efficiency.— Referring again to the first cycle, from the curve (Fig. 3) the curve (Fig. 4) has been drawn, which gives contours of constant efficiency plotted between boiler pressure and back-pressure; from this, knowing the initial- and back-pressure of an engine, it is possible to read off at once the

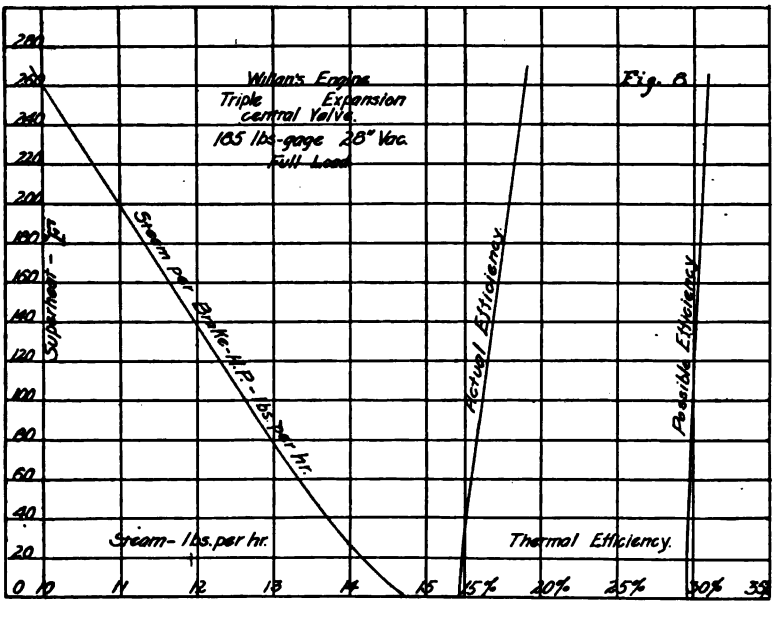


available thermal efficiency. Thus a non-condensing engine, at 155 lb. boiler pressure (gage), has a possible thermal efficiency of 17½ percent., or a triple-expansion marine engine, at 24 in. vacuum and 200 lb. gage, has an available efficiency of 26.5 percent.

Limitations to Theory.— Theoretical results are a valuable guide to the practical in the case of vacuum and boiler pressure, but in the case of superheat they are misleading. In practice, the possible efficiency cannot be obtained and efficiencies referred to the Rankine cycle have not exceeded 80 percent. in the best practice (59th Street). This is partly explained by heat transfer to the cylinder walls, initial condensation, leakage, etc. In bad cases, as much as 60 percent. of the steam is condensed on entering the cylinder. The Rankine cycle takes no account of initial condensation; it assumes condensation proportional to the law of adiabatic expansion. Hence if 2 lb. of

steam are admitted to the cylinder, and 1 lb. is immediately condensed, we may approximate to adiabatic expansion and get a high Rankine efficiency on the remaining pound, but the final result will seem poor because it must be halved to account for the pound condensed.

Tests with Superheat.— Superheating delays the dew point, and while it increases the range of temperature per cylinder, it is able to keep a large part of one cylinder dry and thus the steam contributes some work before it condenses. Practical tests show well in favor of superheat. The curve (Fig. 8) is based on a full-load test of a Willans engine (*Electric Journal,* Vol. III, p. 142).



By superheating, a constant reduction in steam consumption per b.h.p. is obtained, from 14.7 lb. saturated to 10 lb. at 260° F. superheat. On a basis of thermal efficiency this corresponds to a theoretical increase of 1.4 percent., but an actual increase of 4.5 percent. This efficiency, referred to the Rankine cycle, is increased from 49 percent. to 61.3 percent. This test shows a constant efficiency increase to 260° F. Tests on a Westinghouse-Parsons steam turbine

(*Electric Journal*, Vol. III, p. 145) show that the constant increase ceases at about 150° F. Hence it is not usual in the United States to superheat much beyond 100° F.

The Controlling Influence of Load Factor.— The load factor exercises a restraining influence over all increases in the permanent equipment of a station or system. Fixed investments are a constant charge against the system, whereas such economies as they may effect are only realized in proportion to the output. The economies considered — by means of changes in initial temperature, or pressure, or in exhaust pressure — all involve the investment of capital, and their desirability is therefore determined by the load factor. The economy which it is the purpose of this paper to develop is, on the other hand, independent of load factor; it requires no extra expenditure of capital, though probably it demands closer attention on the part of the operator.

The relation of load factor to permissible expenditure is illustrated in a useful way by the following tables. The vacuum equipment for a 27-in. plant costs 25 percent. more than for a 26-in. plant, and for a 28.5-in. plant, twice as much.

MOST ECONOMICAL VACUUM FOR STEAM TURBINES.

(Referred to 30-in. barometer.)

(A) Surface condensing plant; $6 per kw. of main generator capacity. Fixed charges, 12 percent. 1000-kw. plant. Cost of water not included.
(B) Surface condensing plant, including cooling tower and extra cost of land, etc., increasing to $14 per kw. for 28.5-in. plant. Fixed charges, 12 percent. 1000-kw. plant. No charge for water. (N.C.—Non-condensing.)

Load Factor	PRICE OF COAL PER SHORT TON									
	$1.50		$2.00		$2.50		$3.00		$3.50	
%	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
5	N.C.	N.C.	N.C.	N.C.	18	N.C.	20	N.C.	22	N.C.
10	20	N.C.	23	N.C.	25	N.C.	26.5	20	27	22
15	24	17	26.5	20	27	22	27.5	24	27.7	25.8
20	26.5	20	27.3	23	27.6	25.5	27.8	27	27.9	27.5
30	27.5	24	27.8	27	28	27.6	28.1	27.8	28.2	28
50	28	27.6	28.2	27.9	28.3	28	28.4	28	28.5	28

MOST ECONOMICAL VACUUM FOR RECIPROCATING ENGINES.

(Referred to 30-in. barometer.)

(A) Surface condensing plant. Cost $7.00 per kw. Fixed charges, 12 percent. 1000-kw. plant. Cost of water not included.

(B) Surface condensing plant, including water tower and extra land, etc. Cost $11 per kw. for 26-in. plant, increasing to $13 per kw. for 27.5-in. plant. Other conditions as in (A).

Load Factor	Cost of Coal Per Short Ton									
	$1.50		$2.00		$2.50		$3.00		$3.50	
%	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
10.	N.C.	N.C.	15	N.C.	18	N.C.	20	N.C.	22	N.C.
15.	16	N.C.	20	N.C.	22	N.C.	22.5	16	24	20
20.	22.5	N.C.	23	N.C.	23.5	20	24.5	21	25	22
30.	24.	16.	24.5	21.	25.5	22.	26.4	23.	26.8	24.
50.	25.5	22.	26.7	23.5	27.2	23.5	27.5	26.3	27.7	27.

Except where coal is expensive, all plants under 10 percent. should run non-condensing, i.e., for a one-engine station. Where there are several engines, those that carry the day load should be coupled to a condenser.

2. The Equation to the Water-Rate Curve.

The Problem.— In view of that steady improvement in steam engine economy, whereby the cost in steam per unit of power developed is less today than in engines built, say, five years ago, it is inevitable that in stations which have grown up with the increasing demand for power around them, quite a wide range of economy characteristics will be exhibited by the different types represented.

Each unit as added represented the best, or perhaps the cheapest, that the art at the time was producing. Changes in management, changes in prevailing professional opinion, or in manufacturing policy, all are reflected in the equipment. Low speed gives place to high speed, reciprocating engines to turbine, steam equipments to gas power. The result is that 1 kw.-hr. may be produced in one engine for 13 lb. of steam, while another requires 24 lb. It is then a question as to how long we are justified in running the latter unit. If there is ample boiler capacity and the second machine only helps on the peak load for two or three hours per day, it may be best to accept the higher fuel charge; but on the other hand, if the engine is required to run for long periods, or if the load is growing, and if further growth will mean the purchase of extra boilers, then an examination of costs may show it desirable to replace the older unit by a modern and more efficient machine.

There is still another problem. Machines, unless they are intended to be alike, will seldom give similar economies at all loads even if they are equal at, say, full load, i.e., their water-rate curves will differ in shape even though they have the same minimum value. How then shall the load be divided between the two machines? By trying a few points it is easy to see that, with the one exception, an equal division is not the best. We will illustrate it by referring to the curves in Mr. Stott's paper on the "Steam Engine Turbine Unit," page 356.

This brings out also the third case, where the minimum values are not only different but occur at different loads. Mr. Stott shows the water-rate curve for the new unit and above it the water-rate curve for two of the former type of reciprocating engine. Minimum values occur at 11,000 kw. and 9,000 kw. respectively of 13.1 lb. per kw.-hr. and 17.1 lb. per kw.-hr. The unit is flatter than the engine curve. How should a load of, say, 26,000 kw. be divided?

With an equal division, 13,000 kw. on each, the steam consumption would be:

Reciprocating engine,	13,000 × 18.15 = 236,000	lb. per hr.
Turbine unit,	13,000 × 13.25 = 172,000	" " "
	408,000	" " "

With another division, 14,500 kw. on the turbine unit, and 11,500 kw. on the reciprocating engine,

Turbine unit,	14,500 × 13.65 = 198,000	lb. per. hr.
Reciprocating engine	11,500 × 17.45 = 200,000	" " "
	398,000	" " "

Clearly, some other division will give a different result — possibly less — but the difficulty of determining graphically which division will give the minimum value is obvious. If, however, the problem can be attacked analytically, minimum values can be found quite readily. This requires that we express our fundamental data mathematically, in other words, that an equation be found which will represent the water-rate curve. From this equation, it is not difficult to obtain the equation of the curve of total water per hour — the "Willans line."

The area under the Willans line, obtained by integrating its equation between desired limits, under appropriate conditions, gives the number of pounds of steam that the partcular engine would use in

following a load curve between the same limits. One of these conditions is that the load curve is a linear function of time, but in the course of this paper it will be shown that a much wider application is available.

It is clear, then, that if equations of a simple form can be found for the water-rate curves, they will have a wide field of usefulness. Every engineer who undertakes to operate a "mixed" station has problems which they may help him solve. Thus:

1. They will assist in comparing present steam costs with those of a proposed improved equipment.

2. By applying them to the proper reference load curve, the relative suitability, as regards steam consumption, may be determined for a number of alternative engines.

3. By applying suitable load curves, it can be shown that one engine is best suited for railway service, another for lighting or for mill work.

This much for the selection; for the operator:

4. They will show the division of load between engines which will give the least steam consumption for any load.

5. They will show the load range beyond which a machine should not be operated.

6. With an increasing load the best point to switch in a new machine can be determined, and with a decreasing load, the cutting-out point.

7. Which leads in some cases to the interesting conclusion that by putting in the engines a little *earlier* the boilers may be put in a little *later* — and the boilers are the chief expense.

8. Conversely, for a given boiler capacity, or for a given quantity of steam, the maximum kw. output can be determined. The selection of certain load curves as standards of reference will be dealt with in Section 5 in the next issue of the QUARTERLY.

Provided suitable equations can be found which will, as it were, define each engine, they can be applied to the theoretical analysis of many important practical problems, and with the present strong tendency toward "mixed" stations the need for such an analysis is becoming continually greater.

Form of the Equation.— Comparing the water-rate curves from a number of different steam engines, whether turbines or reciprocating engines, throttle or variable cut-off governed, they are seen to be all similar in form though different in shape. Plotted between the axes: Pounds of steam per kw.-hr, or y_1 vertically, and load in kilowatts, or x horizontally, there is a continuous fall with increase of load, suggesting the type of equation, $y_1 = A \div f_1(x)$, where A is a constant. Most curves, however, have a minimum ordinate at, or near, the "rated full load" after which the curve rises again. The above equation can not represent this, so that there must be another term in x, thus: $y_1 = A \div f_1(x) + Cf_2(x)$, where A and C are constants.

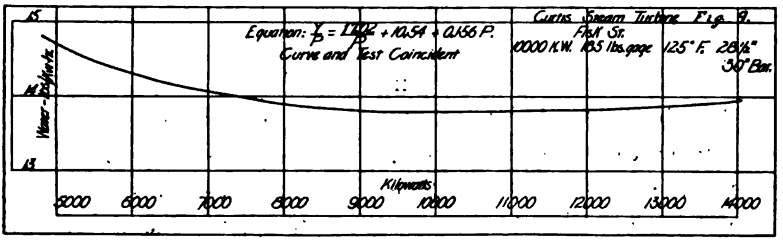
As the only way to determine the equation for any given curve is by trial and error, and as we have first to use the same method to discover the form the equation takes, the work will be cumbersome if $f_1(x)$ remains in the denominator.

By taking points on the water-rate curve and multiplying each by its appropriate load in kilowatts, the curve of total water per hour — the "Willans line" — is obtained, whence it is not difficult to change back to the original water-rate curve if desired. Load in kilowatts plotted horizontally, is x, and water per hour plotted vertically is y. This curve is simpler because, as it rises continuously with the load, all its ordinates seem to be direct functions of the load.

We must now choose a representative curve, and find the desired equation by plotting over it the graphs of such equations as seem suitable. To locate a graph, read off three or four points on the given curve, substitute these values of x and y in the trial equation and thus determine the constants. The trial curve is thereby fixed with three or four points actually in common with the representative curve. Of course, with the equation we are seeking, all points are common, so that the trouble of plotting useless curves can be avoided by choosing one or two further points and seeing if they check. This will be illustrated in connection with a specific example, thus:

To find water-rate equations in a test reported by the General

Electric Co. on turbine No. 8, at the Fisk St. station of the Commonwealth Electric Co., Chicago, Ill. (See Fig. 9)



Kw.	Lb. water per hr. per kw.	Lb. water per hr.	x	y
8,000	13.91	111,280	8	111.3
11,000	13.80	151,800	11	151.8
14,000	13.95	195,100	14	195.1

Try equation of the form $y = A + Bx + Cx^2$ for Willan's line:

$$111.3 = A + B \times 8 + C \times 64 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$151.8 = A + B \times 11 + C \times 121 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$195.1 = A + B \times 14 + C \times 196 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

By substitution:

$$40.5 = 3B + 57C \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)\ (1)$$

$$43.3 = 3B + 75C \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)\ (2)$$

And finally: $2.8 = 18C$, whence $C = 0.156$.
Then $40.5 = 3B + 8.87$, whence $B = 10.54$.
And $111.3 = A + 84.3 + 9.98$, whence $A = 17.02$.
Hence the equation is: $y = 17.02 + 10.54x + 0.156x^2$.

For water-rate: $y_1 = \dfrac{17.02}{x} + 10.54 + 0.156x$.

Check at 12,500 kw.: $x = 12.5$

$$y_1 = \frac{17.02}{12.6} + 10.54 + 0.156 \times 12.5$$

$$= 13.83 \ldots\ldots\ldots \text{correct.}$$

Check at 9,500 kw.: $x = 9.5$

$$y_1 = \frac{17.02}{9.5} + 10.54 + 0.156 \times 9.5$$

$$= 13.81 \ldots\ldots\ldots \text{correct.}$$

Check at 6,000 kw.: $x = 6$

$$y_1 = \frac{17.02}{6} + 10.54 + 0.156 \times 6$$

$$= 14.31 \ldots\ldots\ldots \text{correct.}$$

Similarly for other points. It thus appears that the given curve

and the graph of the equation found are coincident. These curves are plotted in Fig. 9.

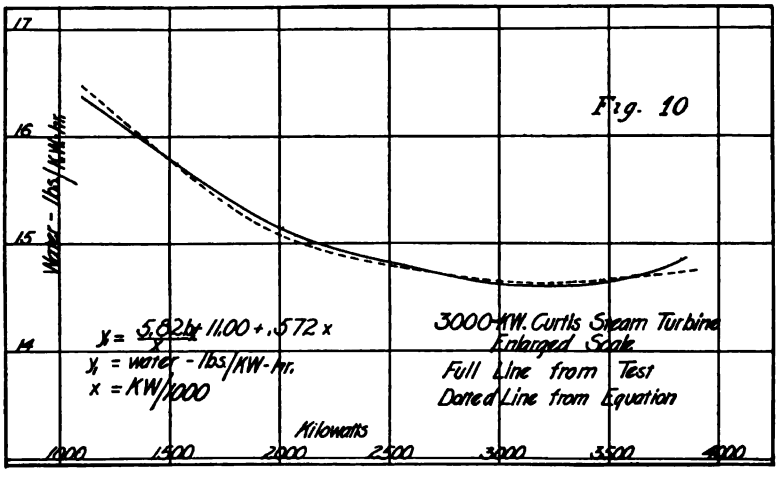
The equation we are seeking then is:

$$\text{Pounds water per kw.-hr.} = \frac{17.02}{x} + 10.54 + 0.156x$$

in which x is the load in units of 1000 kw. This equation is true over the range of the test; it may or may not be true beyond.

In picking points from a curve, to determine the constants in its equation, the points should be chosen to include the whole range of load to which the equation is to be applied; when the equation is only an approximation, the error is thus minimized. This is illustrated in the following example:

To find the water-rate equation for a 3000-kw. Curtis steam turbine curve furnished by the General Electric Co. 180 lb. gage. 125° F. 28-in. vacuum. 1500 r.p.m. (See Fig. 10)



Kw.	Lb. water per kw.-hr.	Lb. water per. hr.	x	y
1,400	15.92	22,300	1.4	22.30
2,200	15.00	33,000	2.2	33.00
3,000	14.61	43,830	3.0	43.83

$$22.30 = A + B \times 1.4 + C \times 1.96$$
$$33.00 = A + B \times 2.2 + C \times 4.84$$
$$43.83 = A + B \times 3.0 + C \times 9.00$$

$$10.70 = 0.8B + 2.88C$$
$$10.83 = 0.8B + 4.16C. \quad C = 0.102$$
$$10.70 = 0.8B + 0.294. \quad B = 13.01$$
$$43.83 = A + 39.03 + 0.918. \quad A = 3.882$$

Equation is: $y = 3.882 + 13.01x + 0.102x^2$

Water Rate: $y_1 = 3.882 \div x + 13.01 + 0.102x$

Check at 1000 kw.: $x = 1$.

$y_1 = 3.882 + 13.01 + 0.102$
$= 16.992$; correct curve point is 16.99

At 600 kw. = 19.54; correct.
" 1800 " = 15.34; "
" 2600 " = 14.74; "
" 3200 " = 14.54; low; curve point is 14.60
" 3400 " = 14.49; low; " " " 14.61
" 4000 " = 14.39; low; " " " 15.04

This curve is represented exactly between 600 kw. and 3000 kw., but beyond these limits it is low.

The points chosen did not go beyond 3000 kw. To obtain accuracy in the overload region, one point must be chosen therefrom. Find another equation, choosing points corresponding to 1400, 3000, and 3400 kw.:

x	y
1.4	33.30
3.0	43.83
3.4	49.67

$$22.30 = A + B \times 1.4 + C \times 1.96 \quad \ldots\ldots\ldots\ldots\ldots (1)$$
$$43.83 = A + B \times 3.0 + C \times 9.00 \quad \ldots\ldots\ldots\ldots\ldots (2)$$
$$49.67 = A + B \times 3.4 + C \times 11.96 \quad \ldots\ldots\ldots\ldots\ldots (3)$$
$$21.53 = 1.6B + 7.04C \quad \ldots\ldots\ldots\ldots\ldots (2) \; (1)$$
$$5.84 = 0.4B + 2.56C \quad \ldots\ldots\ldots\ldots\ldots (3) \; (2)$$
$$23.36 = 1.6B + 10.24C$$
$$1.83 = 3.20C, \text{ and } C = 0.572$$
$$5.84 = 0.4B + 1.465, \text{ and } B = 10.94$$
$$43.83 = A + 32.82 + 5.148, \text{ and } A = 5.862$$

Equation is: $y = 5.862 + 10.94x + 0.572x^2$

$y_1 = 5.862 \div x + 10.94 + 0.572x$

If this curve is plotted above the given curve, it is seen to be low. Add 0.06 to the term without x, making it 11.00, when the curves

then become very close. Equation is an average between 1200 kw. and 3800 kw. with a maximum error of ± 0.5 percent.

Equation for water-rate, $y_1 = 5.862 \div x + 11.00 + 0.572x$ is plotted in Fig. 10.

DISCUSSION OF CURVES WITH EQUATIONS.

Curve (Fig. 9).— Curtis steam turbine. Test reported by the General Electric Co., on turbine No. 8, Fisk St. station, Commonwealth Electric Co., Chicago, Ill. 10,000 kw. 185 lb. gage. 125° F. 28½-in. turbine. Barometer 30-in. Tests were conducted between 5000 kw. and 14,000kw.

The water-rate curve exhibits all the features characteristic of its class. The curve falls continuously as the load increases to 10,000 kw. Near this point a minimum value occurs, after which the water-rate constantly increases up to the maximum overload. Two features are attractive: its slow gradient and its low mean height. It has practically uniform economy between 7500 kw. and 14,000 kw., i.e., over the whole working range. The average value is about 13.78 lb. steam per kw.-hr. Compared with the combined units in the 59th Street station, New York, the latter have a mean value of 13.55 lb. per kw.-hr over the same range, with a minimum of 13.04 lb. As to the equation, the test curve is an exact graph of $y_1 = 17.02 \div x + 10.54 + 0.156x$. Beyond the range stated, it may or may not be coincident. Minimum water-rate = $\sqrt{(A \div C)} = \sqrt{(17.02 \div 0.156)} = 10450$ kw. Correct.

Curve (Fig. 10).— Test on 3000-kw. Curtis steam turbine, drawn to an enlarged scale. Between 1250 kw. and 3750 kw. the graph and the test curve lie closely together, maximum divergence being 0.06 lb. Since the test curve has had to be magnified five times from the original, the divergence may have been caused by a slight error in reading off the original trial points. With the actual values of the test points available, the divergence could be reduced.

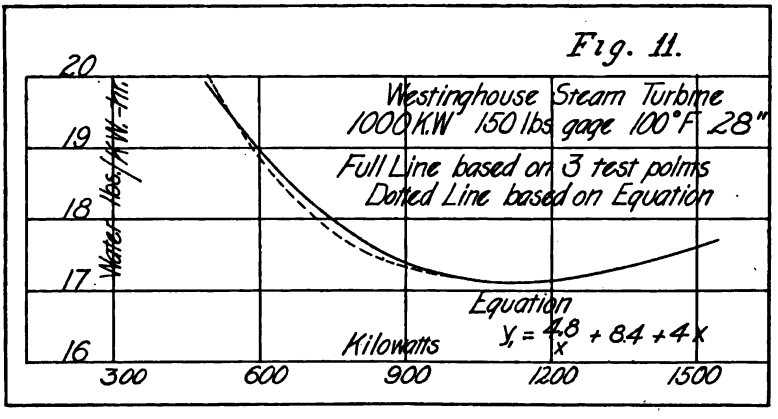
Here, $y_1 = 5.862 \div x + 11.00 + 0.572x$.

Minimum water-rate = $\sqrt{(A \div C)} = \sqrt{(5.682 \div 0.572)} = 3240$ kw.

Curve (Fig. 11).— Westinghouse 28-in. steam turbine, 1000 kw. 150 lb. gage. 100° F. The full line is as drawn by the manufacturer through the three points determined from test.

The equation, $y_1 = 4.8 \div x + 8.4 + 4x$ gives a graph, which is coin-

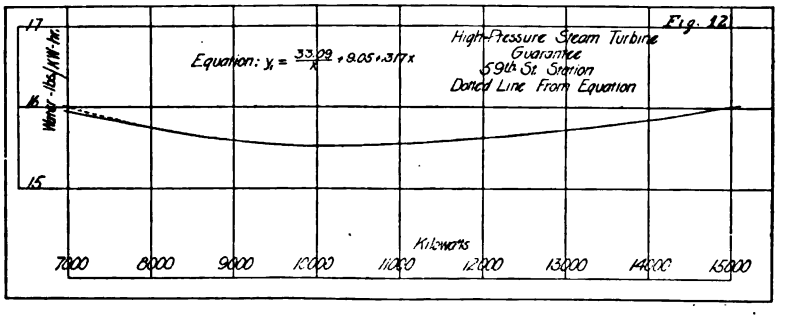
cident from 1550 to 1000 kw. and low to 550 kw. where it crosses. Maximum divergence is 0.11 lb. As there are no test data to the contrary, the dotted curve between 500 kw. and 1000 kw. is as likely to be true as any other.



Minimum point = $\sqrt{(A \div C)} = \sqrt{(4.8 \div 4)} = 1100$ kw. Correct.

Curve (Fig. 12).— High-pressure steam turbine guarantee offered as an alternative in the 59th Street, New York, extension.

The equation $y_1 = 33.09 \div x + 9.05 + 0.317x$ gives a graph that is coincident with the given curve over the whole range, 8000 to 15,000 kw. Note the low value of the coefficient $c = 0.317$. In the engine as adopted, c is either 0.306 (A) or 0.778 (B).



Extension by adding more reciprocating engines was ruled out, in reality, largely by the high value of $C = 1.85$. The large term C causes the curve to bend up sharply on overload. It is desirable to have C as small as possible.

THE CHUICHOS COAL MINE, PERU.

BY LESTER W. STRAUSS.*

This property is of unusual interest for a number of reasons: it is probably the highest operating coal mine in the world — at an altitude of 4600 m. (15,000 ft.); there are no outcrops, and the coal occurs in a vein cutting across the stratification of the limestone.

The coal is of the asphaltite variety. It occurs as an almost vertical vein; it appears as a stringer of carbonaceous matter near the surface, but soon widens out to 5 ft.; at 165 ft. below surface a width of 50 ft. is attained. The coal occurs in lense-shaped shoots, two having been developed; the larger one is 650 ft. long and has a maximum width of 50 ft.; the depth has not been fully exposed. The strike of the vein is N. 40° E.; the dip varies from 45° to 80° N.W., while the pitch of the shoots is to the southwest. In the southwest workings the vein is faulted and apparently thrown to the northwest. The limestone is supposed to be of Jurassic age; ammonites are very abundant.

No exact analyses are available, but the following gives an approximate idea of the constituents: Moisture, 5; volatile matter, 33; fixed carbon, 53; ash, 4; sulphur, 5 percent.

The ash contains vanadic oxide, but apparently not in commercial amount; accumulated ashes in Morococha are stated to contain 8 % V_2O_5. The coal has a dull luster and breaks with a conchoidal fracture. In burning, the coal yields a long flame but never becomes red-hot, except in spots. The hot ash is usually of a tarry consistency when dropping from the grates. The coal is delivered to the consumer almost wholly as fines, not so much due to the structure as to the necessity for llama transportation; the fines burn readily, although requiring considerable stoking, or poking, according to whether fired under a boiler or in an ordinary stove.

The coal has been opened through a tunnel 1115 ft. long, driven in the footwall, at right angles to the strike, and cutting the vein at a vertical depth of 165 ft. below the outcrop. The northeast drift was 394 ft. long and the southwest drift 1640 ft. long in December, 1911; below this level a few winzes had been sunk, the deepest being about 35 ft. No pumping or hoisting is done. The mining is all pick-work, thus avoiding the making of an excess of fines. The

* Lima, Peru. E. M., Columbia, 1900.

coal stands well in place, but the walls are generally soft, due to selvage. Square sets of 8×8-in timbers are used extensively in the wide stopes, which are then filled with waste or country rock; the sets are extracted later except those of the main or central entry. The filled sets are kept close to the working face. The broken coal is shovelled into cars, which hold 1400 lb., and trammed out to the surface, by gravity, in trains of three cars, the empties being hauled back by mules; the round trip takes 35 min. from the southwest working (about 5500 ft.).

The question of transportation is a serious one. At present llamas are used, each carrying a sack of 115 lb. The usual carrying load of these useful beasts of burden, peculiar to the highlands of Peru and Bolivia, is 110 lb. The freighters charge 20 centavos per sack from the mine to railroad, about 20 kilometers by trail, all down hill. The railroad tariff from this point, Huari, on the main line of the Central Railroad of Peru, to Morococha (the principal point of consumption) is 3.00 pesos per metric ton for car lots; the haul is 87.5 kilometers and in greater part uphill. Coal is also shipped on llamas direct to Morococha, 60 kilometers over an up and down hill trail, at a cost of 45 centavos per sack, or 8.62 pesos per metric ton. The llama haul necessitates the coarse lumps to be broken to 3-in. pieces or finer; otherwise the llamas suffer from sore backs. At some later day a narrow gauge railroad, or aerial tramline, might be warranted to connect the mine with the railroad at Huari. The present output is about 900 short tons per month. For this production 25 men, comprising miners, trammers and timbermen, are employed per shift, working only during the day. No work is done on Sundays but a shift goes on Saturday night. Miners and trammers are paid 1.20 pesos and ordinary labor 1.00 peso per day of nine working hours; the actual shift is from 7 A. M. to 5:30 P. M.

The price of the coal has recently been raised to 26.00 pesos per metric ton delivered in Morococha; coal brought from the coast — either Australian or Cardiff — costs 35.00 pesos delivered, and it is in considerable demand for power and domestic purposes.

The above values, in Peruvian currency, can be taken on the basis of 50c. U. S. gold to the peso.

ENGINEERING LIBRARY EFFICIENCY.

BY W. DAWSON JOHNSTON.*

Very little has been written about engineering libraries and engineering literature, perhaps because we have been more active in producing this class of literature than in using it; perhaps, because we have not thought much about the use of it. It will be granted, at any rate, that we have not thought about it enough.

Of all engineering libraries, that of an engineering school is undoubtedly the most important, because it is there as nowhere else that the engineer has an opportunity to learn the use of engineering literature, and of all engineering school libraries those located in the metropolitan centers are the most important, again, because they may serve as professional libraries for alumni as well as for the students.

The following notes on engineering school libraries, their organization and administration, have been gathered by an examination of college catalogues and reports, and by correspondence; they are published here for the information not only of alumni of engineering schools, but of all who are interested in higher standards of engineering education.

BUILDING CONDITIONS.

The excellence of the library service in any institution may be measured by building conditions; an engineer would, I suppose be one of the last men in the world to question this. Judged by this standard, engineering schools are as badly off as other schools. Rooms devoted to library purposes are, as a rule, badly located, badly distributed and badly furnished.

At one or two institutions the general university library is still thought sufficient. There is no doubt as to the value of a general library to an engineering student, indeed, this constitutes one of the advantages of a University school of engineering over other schools, but its distance from engineering laboratories even on the most crowded campus, and its organization in the interest of general readers, make a department library essential also.

* Librarian, Columbia University.

It is amazing that anyone should have long considered one library, and that a general one, sufficient for engineers, but it is equally amazing that administrative authorities, in their effort to supply better reading room facilities, should have gone so far in the other direction. In looking over the returns, one is almost persuaded that the smaller the engineering school the more department libraries it has. However that may be, it is true that there is a difference in this respect between university schools of engineering and polytechnic schools. At universities, more library work is expected from students and less from professors; there is more advanced instruction, more reading as well as more laboratory work, and a greater variety of reading as well as a greater amount. On the other hand, instructors have less time to give to library administration.

These conditions have made it necessary to secure more library room both for readers and for books. Department libraries of the old type, small and scattered, consisted mostly of walls and doors. The walls served to keep members of other departments out and offered opportunities for wall shelving which were irresistible. The doors, however, were of more questionable advantage; if a book were wanted very much the door was locked, and if the door were unlocked the book had disappeared. The department library of the new type is primarily a librarian.

The transition from the one to the other is well illustrated in the experience of such universities as Wisconsin and Minnesota. The story of the former is told in the last report of the librarian:

"While for many years the special libraries of the college of law and agriculture have been housed separately with special librarians and catalogues, the collections in the field of engineering and technology have been included in the general library. At the engineering reading room in the engineering building have been kept only the current files of engineering periodicals and a small collection of the engineering reference books. With the rapid growth of the university and the library, I have for some time felt that the engineering students are not making satisfactory use of the engineering section of the library and that, under present conditions, it was not possible for the general library staff to give adequate service to this portion of our constituency. The matter was therefore canvassed with the dean and faculty of the college of engineering. As a result of our conference, recommendation was made to the regents that provisions be made in the enlargement of the engineering building for a separate engineering library. This recommendation received favorable consideration by the regents and quarters for the college or department engineering library are now being prepared. While we fear that both reading room and stack for this new branch library will very soon prove quite inadequate, they will occupy

all the space that could be spared in the engineering building for the purpose at the present time. The engineering library will be in the immediate charge of a young man with engineering education and experience, who seems to be well qualified for the work. I hope and believe that the institution of this branch engineering library will prove of great and increasing benefit to the faculty and students of the college of engineering."

At Minnesota, too, it is expected during the present year to install the engineering collections, hitherto separate and administered directly by the different engineering departments, in one of the new engineering buildings, and place a librarian in charge.

At the polytechnic schools, on the other hand, where the general library has a more special character, a department library distinct from the laboratory collections is unnecessary. At the Rensselaer Polytechnic Institute, for example, the general library, a new building within a few hundred feet of all the other buildings of the school, is sufficient. The reading room has a seating capacity of 180. At the Worcester Polytechnic Institute, on the other hand, the small seating capacity of the general reading room (35) has driven the authorities to the establishment of five department reading rooms which are looked after by instructors and graduate students.

At Yale it is required that department libraries shall be housed in fire-proof buildings. I do not find, however, that this requirement is general among universities, or that any other requirements are widely recognized. The department library lies between the Scylla of administrative centralization and the Charybdis of departmental isolation, and, therefore, gets not what it needs but what it can, and what it can get may or may not be what it needs.

Collections.

In the large universities about 5.3 percent. of the expenditure for books is for the literature of engineering, and about 24 percent. of the expenditure for books on engineering is for periodicals. Analysing the expenditure by subjects: at the University of Minnesota, for example, the expenditure for books on mining engineering constitutes 43 percent. of the entire outlay for books on engineering; that for mechanical engineering, 34 percent.; that for civil engineering, 15 percent.; and that for electrical engineering, 8 percent. These figures would have more significance if they represented a period of years and the experience of several institutions of the same class.

It is remarkable how few instances there are of endowments for engineering libraries and how few gifts they have received. Perhaps the most notable of them is the recent gift of $5000 to Brown University by Dr. Corthell, as an endowment for the remarkable collection of works on river and harbor engineering given by him to the University, together with perpetual subscriptions to the leading engineering congresses, societies, and periodicals.

Nor have gifts of collections of books been numerous. In 1898 Professor Thomas Egleston gave a collection of about 1000 volumes to Columbia University on condition that the serials, which constituted the larger part of the gift, be continued. An unusual feature of the gift was that the donor was careful to give no book which the University already possessed. More remarkable still was the gift, just referred to, made by Dr. Corthell to Brown University. This included over 7,000 books, pamphlets, reports, maps and plans relating to river and harbor engineering, together with a card index containing over 20,000 entries. The collection of engineering works, 876 volumes, 478 pamphlets, and 185 maps, charts and photographs presented by Mrs. W. E. Merrill to the University of Cincinnati may be noted also, and the library of engineering presented to Princeton University by the class of 1878.

Reading Rooms.

The *larger* part of the engineering collections are stacked either in the general library or adjoining the department reading room; the most *useful* part of the collection is shelved in the reading rooms.

The collections in the reading rooms consist of books and periodicals relating to subjects taught in more than one department and are consequently shelved only in the general reading room, or duplicated in the department reading room, or shelved there temporarily. At the Massachusetts Institute of Technology, for example, sanitary science, instruction in which is given in the departments of biology, chemistry and sanitary engineering, is placed in the general reading room. At Yale, files of journals as well as treatises and manuals are duplicated extensively in the department reading rooms and purchased with department funds, though the department reading rooms are open from early morning until late in the evening. At

Purdue only the current numbers of periodicals are placed in the department reading rooms and these duplicate those in the general library. At Harvard the temporary deposits constitute 7 percent. of the collections in the engineering reading rooms. They are usually made for a semester only.

In theory, the seating capacity of a reading room should increase with student attendance; in fact, conditions vary greatly. At Pennsylvania there appears to be one seat for every 3.66 students, while at Missouri there is one for every 32.1 students; that is a student has about one-tenth the chance at Missouri that he has at Pennsylvania. The average appears to be about one seat to every 13 students.

ENGINEERING LIBRARIES

Institution	Reading Room Collections		Annual expenditures for		Reading Rooms	
	Volumes	Current Periodicals	Salaries	Books	Seats	Students per Seat
Minnesota	....	149	....	$ 664	...	....
Nebraska	6,000	70	$ 550.	1127	50	8.35
Michigan	8,500	105	1200.	1200	60	22.2
Iowa	5,000	117	750.	2500	75	6.3
Pennsylvania ...	5,000	50	....	1000	200	3.66
Worcester	4,925	57	....	350	100	5.14
Missouri	3,700	77	200.	1190	20	32.1
Wisconsin	....	175	....	....	100	7.47
Harvard	8,433	100	....	....	...	....
Columbia	3,083	81	....	900	...	....

In the use of the collections, it has been ordinarily held that books in a general library might be borrowed while those in a department reading room are held for reference only. In practice, however, the contrary appears to have been the rule, the more accessible works being the ones which are borrowed, either lawfully or unlawfully, while the less accessible are seldom used.

Whether collections are to remain in department reading rooms permanently or only temporarily, and whether they are to be duplicated or not, depends to a large extent upon the length of the hours which the reading room is open. Perhaps the majority of engineering libraries are kept open only during the school year. This makes little difference when they are used only by the students,

but when the use is more general this is an important consideration. Hours open vary from 8½ at the Worcester Polytechnic to 11½ at the University of Michigan.

ADMINISTRATION.

In the administration of engineering school libraries it is now generally held that they must be subject to supervision of the University librarian and cared for by a trained and experienced assistant. Such an assistant will be able to attend to all the work of the department library, including its cataloguing, as at the University of Michigan. When a clerical or student assistant is employed, however, the cataloguing must be done by the general staff, as at Yale and Missouri. Ordinarily this expense is met out of the library appropriation, but where a distinction is made between library books and department books the latter are catalogued at the expense of the department.

A STUDY OF ORES FROM AUSTIN, NEV.*

BY H. B. TAYLOR.

The ores, a study of which forms the basis for this paper, came from Austin, Nev., and mainly from the Lander hill section of the camp. The town is situated at the southern terminus of the Nevada Central Railroad, which connects with the Southern Pacific at Battle Mountain. It lies on the west slope of the Toyabe range at an elevation of 6608 ft., and near the head of a gulch which leads down to the Reese River valley. It is 58 miles due west of Eureka.

Austin is one of the oldest mining camps in Nevada, having been discovered in 1862. The richness of the veins helped to give Nevada its first mining boom. The necessary value per ton in the early days was $100, in order to cover the heavy charges for mining, freight and treatment. It must be recognized that the value of silver then was about twice what it is today.

The best of the ore was found on Lander hill, in fissure veins which had granite for their wall rock. There were a large number of parallel veins with a general N.W.-S.E. strike, and a dip which varied between 15° and 70° into the hill. These fissure veins were filled with quartz and were usually very narrow, ranging from a few inches to 30 in. wide. In places they were frozen to the walls, while in other places a well developed gouge seam appeared between them and the wall rock.

The ore first found contained chlorides of silver, with accompanying oxides and carbonates of iron and lead, and occurred in pockets, but as shafts were sunk on the veins, shoots and pockets of ruby silver, mixed with sulphides, were found. The minerals reported by early observers were pyrargyrite, proustite, stephanite, polybasite, tetrahedrite, enargite, argentiferous galena, zinc blende which was thought to be silver bearing, copper pyrites and pyrite. The gangue was in most cases quartz, but manganese spar and calcite also occurred.

The distribution of the ore in the veins themselves was irregular, ranging from small pockets to large shoots, the latter occurring most

* Thesis submitted for the degree of Master of Arts, Columbia University, April, 1912.

commonly where the veins were fractured by a north and south faulting. The pay streak was not wide, ranging from 2 to 6 in. and rarely reaching a maximum of 24 in. The veins themselves were very narrow and in depth united to form a fewer number. The large shoots ranged from 100 to 200 ft. in length and depth and were about 6 in. wide. In these mineralized portions of the vein a beautifully banded structure was noticed. The greatest portion of the vein filling consisted of barren white quartz containing sparsely disseminated sulphides.

After the first fissuring and vein formation, a faulting occurred in a north and south zone, which dips east at about 20°, with throws varying up to 50 ft. Along the lines where these faults cut the veins, ore shoots sometimes were formed.

The third and final movement was one that had a N.E.-S.W. strike, and cut off all the veins in depth. This fault is normal and has a throw of approximately 100 ft. On account of the number of similar parallel veins, this fault made it extremely difficult to follow any one vein. The basal rock is a granite, in which the rich shoots in the veins appear; this granite is the only rock to be considered in this paper. The other eruptives in the district are flows, among which are trachytes and amygdaloidal rhyolites. The granite forms the backbone of Lander hill, and is supposed to underlie all the other rocks in the district. It is a soda granite of light color and an even texture. Farthest away from the veins it is not very acid, having only a fair amount of free quartz, but this constituent increases as the veins are approached. Besides the quartz, large grains of pink orthoclase are seen and smaller ones of a greenish feldspar, probably albite, which forms an apparently larger portion of the granite than the orthoclase. Brown plates of biotite occur. As the rock approaches the veins and becomes more acid, muscovite appears associated with the biotite. Titanite, apatite and hornblende make up the accessory minerals. This granite does not seem to be much altered except in proximity to the veins, and also in occasional spots.

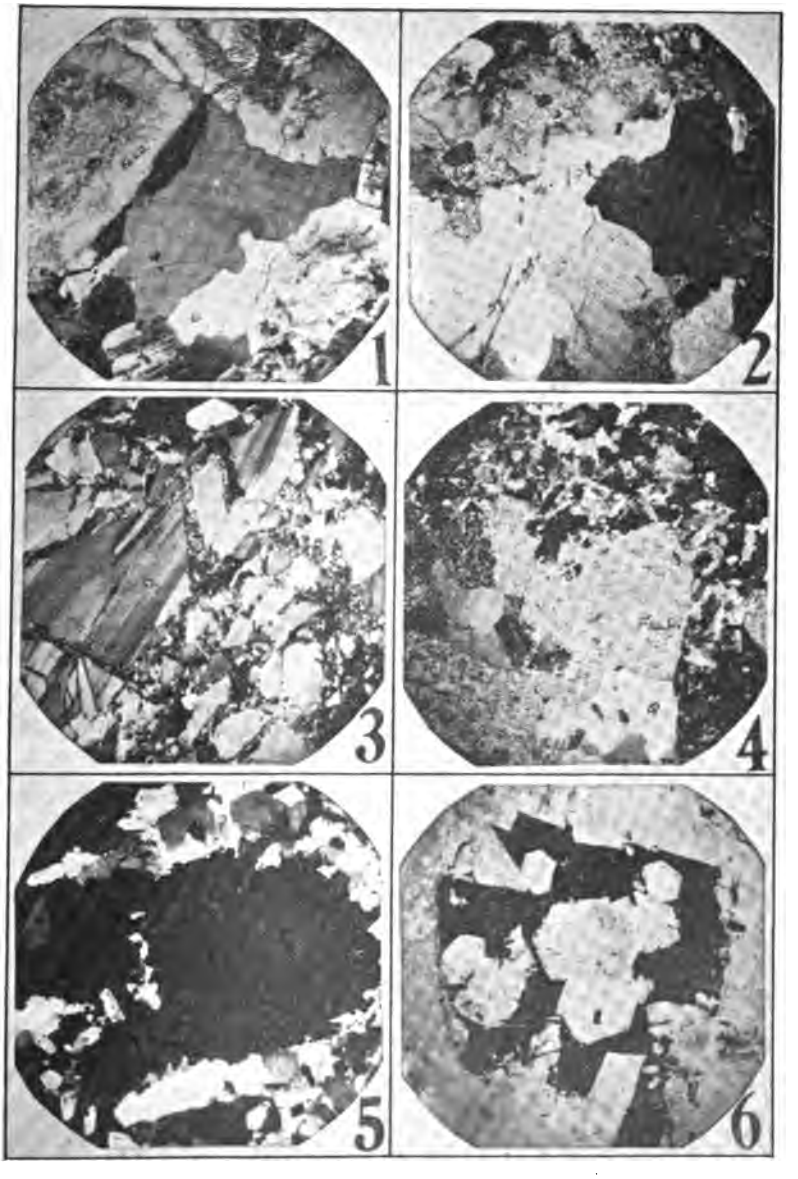
The orthoclase alters to sericite while plagioclase goes to sericite and calcite. In the granite situated away from the veins, this alteration is just beginning, but the feldspars in that portion which oc-

curs near the veins are entirely altered to sericite. The biotites show varied alteration, at times being bleached to a white mica; at others, partly changed to epidote and calcite but with the unaltered part remaining reddish brown. The alteration seems to take place nearest those quartz grains which show a faint interfingering around the edge, and also along lines of crushing.

The quartz found in the granite is of special interest on account of its close resemblance to that which constitutes the first vein filling. A study of this mineral shows that it was the latest to crystallize in the granite, as it encloses groups of feldspars and biotites. It occurs in segregations from which offshoots branch out, filling interstices between the feldspars. In the segregations of quartz, rounded grains of feldspars and shreds of biotite are at times included. When the feldspars lie in proximity to the interfingering quartz grains, they are more altered than those farther removed. This interfingering in the quartz increases as the veins are approached. This seems to point to the fact that the magma, from which the granite was derived, was heavily charged with mineralizers. The quartz of the granite bears such a relationship to the rest of the minerals of that rock that we cannot doubt that it is one of the original constituents.

A certain amygdaloidal rock is very interesting because of its heavy silicification. In the hand specimen the rock has a glassy ground-mass containing amygdules filled with secondary quartz. Some of the smaller cavities are entirely filled. Under the microscope, the rock has a felsitic texture, which is of secondary nature and is derived by devitrification of the ground-mass. In the slide, spherulites are seen around phenocrysts of quartz, while other quartz crystals are scattered sparingly through the section. The minerals forming the phenocrysts are quartz, albite and a small amount of orthoclase. These crystals are broken and the quartz shows slight resorption. Introduced quartz fills the amygdules in the rock. A small amount of hematite is included in the quartz filling of these cavities. The rock is a surface flow and the cavities show that it was well charged with gases. We may call it, for want of a better name, a spherulitic amygdaloidal aporhyolite.

In going over the thin sections of the vein material, it at once ap-



1. Granite country rock, showing interfingering structure of quartz.
2. Wall rock of vein, showing segregation of quartz.
3. Vein material, showing brecciated structure.
4. Vein material, showing altered feldspar and biotite.
5. Vein material, showing structure of quartz around the ore minerals, ruby silver associated with dark sulphide.
6. Vein material, showing ruby silver filling space between quartz grains.

pears that additions have been made to the fissure filling at three different stages. Large segregations of quartz occur which seem to form fragments in the vein. This is a barren quartz and the first vein filling consisted of it. The second introduction, which occurred after the fracturing of the first filling, comprised the ore minerals and associated quartz. The final addition consisted in small veinlets of quartz, with which phase the process of deposition from the uprising solution was brought to a close. Calcite and secondary enrichment products occur, but are due to meteoric waters.

The ore minerals which were recognized in the slides are the following: tetrahedrite, galena, zinc blende, chalcopyrite, pyrite, enargite, chalcocite, pyrargyrite and xanothoconite. The primary minerals seem to have been deposited from solution at about the same time. They embrace tetrahedrite, galena, zinc blende, chalcopyrite and enargite. Some of the zinc blende crystals are full of inclusions of a black sulphide, which may be argentite, while other sections of blende are light yellow and contain no inclusions. These last are due probably to a solution and redeposition of the zinc blende, and are not of a primary nature.

The galena and tetrahedrite are intimately intergrown and are at times contained in pyrite crystals, while in other cases they contain pyrite. The galena is reported to be silver bearing, but it does not show any included argentite. The silver may replace to some extent both the copper in the tetrahedrite and the lead in the galena.

The minerals which owe their origin to secondary enrichment are chalcocite, pyrargyrite, and xanthoconite. The chalcocite forms films around the chalcopyrite grains and does not occur in any great amount in the slides studied. The pyrargyrite is a deep red mineral and with it in some cases is associated a yellow-brown mineral which in almost every case appears as an aggregate. This mineral occurs nearer the zone of oxidation than does most of the pyrargyrite. Two crystals were noted which gave an extinction of approximately 10°. The mineral usually occurred associated with the ruby silver, and satisfied the optical tests for xanthoconite. Both xanthoconite and pyrargyrite are secondary and both were probably produced by the enrichment of antimony and arsenic bearing sulphides.

The ruby silver in several cases is associated with tetrahedrite. It appears in cracks through the tetrahedrite and around its edges. This would seem to point to the alteration of tetrahedrite to pyrargyrite through the metasomatic replacement of the copper by the silver in descending surface waters.

The gangue minerals are of two generations, as seen in the slide. First, the original quartz filling, which has been brecciated, making passages for the rising mineral-bearing solutions. A small amount of granite has also been brecciated and included in the vein material in the form of grains of mica and altered feldspar. The feldspar has been altered to sericite while the biotite seems only to have been bleached. The quartz that was introduced along with the ore minerals makes up the fine-grained ground-mass and has enlarged the original quartz fragments by secondary growth.

The following equations are given to show how these reactions might occur:

1. $FeS_2 + 3O + H_2O = FeSO_4 + H_2S$
2. $4FeSO_4 + 2O + 7H_2O = 2Fe_2O_3, H_2O + 4H_2SO_4$
3. $Ag_2S + H_2SO_4 = Ag_2SO_4 + H_2S$
   or $Ag_2S + H_2O + 4O = Ag_2SO_4 + H_2O$
4. $Cu_8Sb_2O_7 + Ag_2SO_4 = 2Ag_3SbS_3 + Cu_2S + 3CuSO_4$

Xanthoconite will be derived if silver replaces the copper in enargite, according to the equation: $2Cu_3AsO_4 + 3Ag_2SO_4 = 2Ag_3AsS_3 + 2CuS + 2CuSO_4 + Cu_2SO_4$. This derivation of xanthoconite can not be proved by anything seen in the slides, but the association with pyrargyrite lends foundation to the supposition.

The original filling of the veins consisted of quartz grains which rarely have their own crystal boundaries. Interfingering appears in many of the quartz grains and is more pronounced than in the quartz of the granite. This vein quartz, therefore, may be believed to have some close relationship to that in the granite, and may have been derived from the cooling magma either as residual quartz in a state of fusion, and forced up into the fissures, or carried into them in solution in the mineralizers held in the magma.

That this vein material was heavily charged with mineralizers is shown by the fact that, at or near the contacts, the feldspars have been entirely altered to sericite, and the biotite has been leached to

a white mica resembling muscovite. This first filling of quartz has nothing to do with the mineralization of the vein, which occurred after this quartz was brecciated. Through the channels afforded by movements along the first vein filling, the ore-bearing solutions ascended. In those movements, shooted zones were produced in the veins, so that a number of parallel channels were afforded. In these the ore was deposited. The vein was not entirely crushed by these movements, but only in places. The granite wall rock was similarly affected.

The veins around Austin thus shows a banded structure, due to parallelism of the sheeting planes through which the mineral-bearing solutions rose. Thus the mineralized bands are of the same age, while the barren quartz bands, consisting of the brecciated fragments, are older than the ore filling. The banded structure of these veins, therefore, is not explained on the same basis as in the case of typical Freiberg veins, which originally gave the name to this kind of vein structure.

The origin of the Freiberg banded structure is explained on the supposition that the ore was deposited in an open fissure, and that the precipitation of the minerals on the walls proceeded outward to the center. The main point is that the fissure must be open while the deposition is proceeding. The contrast between bands is due to a difference in mineral contents. The formation of banded veins of the Austin type presupposes no open fissure but parallel planes of fracture forming passages for rising mineral solutions, in which channels the ore is deposited.

Deposits of the latter variety will be characterized by pockets and shoots, and the ore will not usually be distributed regularly throughout the vein. To this type the greater number of the Austin veins belong, since only barren quartz is found, while the ore is irregularly distributed in shoots in the vein, along brecciated zones. The bands are often seen to branch around the larger brecciated quartz grains, and then join again. A thin section from anywhere in the banded part of the veins will show these characteristics.

It is impossible to say from what source the mineral-bearing solutions were derived, but they may be thought to be the dying effects of the granite magma; for they started soon after the formation of

the quartz veins and at the time of their brecciation. As the magma was probably highly charged with mineralizers in the last stages of cooling, mineral-bearing hot water may have resulted.

In conclusion, we see that the original quartz veins are intimately related to the granite intrusive and are probably the end phase of that vulcanism. The results may have been veins, in their true sense, or pegmatite dikes. Afterward, the quartz veins were crushed and the ores were deposited in the brecciated parts, a relationship which will explain the distribution of the mineralization in ore shoots and pockets. To this crushing and mineralization is due the banded character of the veins. A third fact is that the dark ruby silver, pyragyrite, in these veins is due to secondary enrichment, and is found only in the enriched sulphide zones. This interpretation explains its occurrence in almost every vein in which it is found.

NOTES ON DIAMOND DRILLING.

BY ALBERT E. HALL.*

As the prospecting of a mining property by diamond drilling requires a large expenditure, the owners expect to get the desired information as quickly as possible. One of the most important items in the cost of this work is the time required for operations other than actual drilling, which may properly be called lost time; of this, pulling and lowering the rods account for the greater part. The proportion of time lost can be reduced by good judgment on the part of the drill runner.

The following records of eight shifts on two diamond drills at the Dome mine, South Porcupine, Ontario, may assist in realizing the importance of this matter:

Shift I. Depth 735 ft.

Operation.	Time Drilling	Time Lost
	h. m.	h. m.
Drilling (8 ft.)....	1 30	
Pulling rods		35
Dropping rods		15
Drilling	2 53	
Lunch, 55 min.		
Pulling rods		34
Changing bit		02
Dropping rods		22
Drilling	3 27	
No water		40
Total, excluding lunch time ...	7 52	2 28
Time efficiency.	76%	

Shift II. Depth 770 ft.

Operation.	Time Drilling	Time Lost
	h. m.	h. m.
Dropping rods		22
Drilling (8.8 ft.)..	3 57	
Pulling rods		37
Removing core, etc.		01
Dropping rods		23
Lunch, 1 h. 26 m.		
Blowing cylinders.		02
Running over core.		07
Repairing gear ...		02
Running over core.		09
Drilling (2.25 ft.).	1 30	
Pulling rods		34
Fixing core and bit.		02
Dropping rods		22
Drilling	1 32	
Total, excluding lunch time.....	6 59	2 39
Time efficiency..	72.6%	

* Engineer with the Dome Mining Co., South Porcupine, Ont. E. M., Columbia, 1911.

Shift III. Depth 803 ft.

Operation.	Time Drilling	Time Lost
	h. m.	h. m.
Pulling rods		30
Fixing core and bit.		02
Dropping rods		19
Drilling (4 ft.)....	1 52	
Pulling rods		27
Fixing core and bit.		02
Dropping rods		19
Drilling	1 09	
Pulling rods		25
Dropping rods		20
Drilling (8 in.)....		34
Pulling rods		28
Dropping rods		19
Drilling (3.1 ft.)..	1 31	
Pulling rods		28
Fixing core and bit.		02
Dropping rods		21
Drilling	0 52	
Total	5 58	4 02
Time efficiency....	59.7%	

Shift IV. Depth 820 ft.

Operation.	Time Drilling	Time Lost
	h. m.	h. m.
Drilling	38	
Pulling rods		22
Fixing core and bit.		02
Dropping rods		11
Fishing for core...		06
Pulling rods		28
Fixing core and bit.		03
Dropping rods.....		19
Running over core.		12
Drilling	1 49	
Pulling rods		32
Fixing core and bit.		02
Dropping rods		18
Drilling (3.67 ft.).	2 01	
Pulling rods .....:		31
Fixing core and bit.		02
Dropping rods		22
Drilling	1 46	
Total	6 14	3 30
Time efficiency...	64%	

Shift V. Depth 550 ft.

Operation.	Time Drilling	Time Lost
	h. m.	h. m.
Dropping rods		30
Drilling (4.67 ft.)..	2 40	
Pulling rods		32
Dropping rods		23
Drilling (2.75 ft.).	1 20	
Pulling rods		35
Dropping rods		30
Fishing for core...		05
Trial pull and re-running		05
do. do.		07
Pulling rods		25
Dropping and hammering		25
Fishing		03
Pulling rods		25
Changing bits		09
Dropping rods		29
Pump repairs		42
Running to bottom.		35
Drilling	0 35	
Total	4 35	6 00
Time efficiency ..	43.3%	

Shift VI. Depth 572 ft.

Operation.	Time Drilling	Time Lost
	h. m.	h. m.
Dropping rods		30
Drilling	2 15	
Trial pull		05
Re-running to bottom		16
Drilling	0 16	
Pulling rods		29
Removing core and examining bit ..		06
Dropping rods		22
Drilling	0 55	
Drilling	0 35	
Pulling rods		30
Examining core and bit		05
Dropping rods		26
Drilling (1.8 ft.)..	1 12	
Pulling rods		47
Fixing core and bit		02
Dropping rods		16
Drilling (1.75 ft.).	0 55	
Pulling rods (part)		47
Total	6 08	4 41
Time efficiency ..	56.7%	

Shift VII. Depth 600 ft.			Shift VIII. Depth 626 ft.		
Operation.	Time Drilling	Time Lost	Operation.	Time Drilling	Time Lost
	h. m.	h. m.		h. m.	h. m.
Drilling (1.75 ft.)..	1 00		Drilling (8 ft.) .	3 13	
Pulling rods		30	Pulling rods		35
Fixing core and changing barrels.		05	Removing core and fixing bit		10
Dropping rods		33	Dropping rods		22
Reaming (6 ft.)...		1 19	Running over core		04
Drilling	1 43		Drilling	0 36	
Lunch, 1 h.			Lunch, 1 h. 5 m.		
Drilling	3 00		Drilling	2 04	
Pulling rods		34	Pulling rods		33
Fixing core and bit.		11	Fixing core and bit.		08
Dropping rods		19	Dropping rods		18
Drilling	0 46		Drilling	1 37	
Total, excluding lunch time ...	6 29	3 31	Total, excluding lunch time	7 30	2.10
Time efficiency ..	62.9%		Time efficiency ..	69.7%	

The above records show that in some cases less than 60 per cent. of the shift was used in actual drilling; the highest efficiency was 76 per cent. This is one of the reasons for the high cost of diamond drilling. Another item on which the judgment of the runner has a great influence is the speed of rotation adopted. The hardness and character of the rock are the controlling factors, which must be estimated in the light of observation and experience in order to determine the proper speed. Again, with a lightly built friction gear, if too great a pressure is applied to the bit in the effort to accomplish faster work, the probability of deflection in the hole is much increased. In one hole in which the bit was forced down pretty hard, the inclination decreased from 40° to 10° at 1500 ft. depth. The following table shows the speeds of several of the holes under consideration:

Speeds	Hole 00000		Hole 00		Hole 000		Hole 0000		Hole Vo	
	per shift	per day	per shift	per day	per shift	per day	per shift	per day	per shift	per day
Maximim	33′6″	50′10″	36′9″	60′5″	30′10″	48′11″	30′ 4″	45′2″	32′4″	59′1″
Minimum	7′1″	15′ 4″	6′5″	20′6″	5′11″	22′ 0″	6′ 7″	20′2″	4′0″	9′0″
Average	17′1″	34′ 2″	17′6″	35′0″	16′ 9″	33′ 5″	15′11″	32′0″	16′2″	32′4″

Speeds	Hole V00		Hole V100		Hole V1100		Hole IX00		Hole XOX	
	per shift	per day	per shift	per day	per shift	per day	per shift	per day	per shift	per day
Maximum	37′11″	70′ 8″	30′1″	40′0″	23′ 0″	34′4″	35′2″	52′4″	28′ 6″	39′10″
Minimum	2′ 0″	12′11″	6′0″	11′0″	3′11″	9′1″	8′0″	10′4″	5′10″	11′ 9″
Average	17′ 2″	34′ 4″	15′1″	30′2″	not finished		14′1″	28′2″	13′ 0″	26′ 0″

During a period of 5½ months in which two drills ran for the whole time, and two drills for 1½ month only, (equivalent to one drill for 14 months) a total of 10,278 ft. of hole was drilled, or 730 ft. per month per drill. The drills worked 26 days per month, on two 10-hour shifts. This gives a general average of 14 ft. per shift.

A third factor on which the skill of the runner has a great influence is the cost of carbons per foot. The actual wear depends directly on the character of the rock, but the runner has to decide at any given time whether to use the bit for another run or to put down a new one. Several of the holes above mentioned cost, for carbons, less than 15c. per foot. Another hole, in which all new stones were used, showed a cost of over $2 per foot for carbons; this was due to the breaking of several of the stones. Being unworn, they had sharp edges and corners, which accounts for the breakage and chipping.

Drilling at the Dome mine is done on contract, but is paid for by the month and not by the foot. The mining company supplies fuel and water, or allows 10c. per foot for water and 14.6c. per foot for coal.

ABSTRACTS—ANALYTICAL CHEMISTRY.

BY E. WALLER.

APPARATUS — REAGENTS — MANIPULATION.

Marking Porcelain Crucibles.—Yoder *(J. Ind. Eng. Chem.,* IV, 567) The crucibles are cleaned by heating for half an hour in HNO_3(1:1). The parts to be marked are wetted with a sizing of 5% gelatin, and dried. When dry, the mark may be made with a rubber stamp wetted from a pad soaked in $PtCl_4$ solution, containing 12 to 15% Pt. Then heat gently to burn off the gelatin and reduce the Pt. Finally heat for 30 sec. in the flame of a blast lamp. Many of the pigments used in china painting may also be made serviceable. The marks should be stamped on in "fat oil" (partially oxidized linseed oil) and the pigments dusted on with a camels-hair brush. The marks are then "set" by firing, as already described.

Ammonia — Nesslerizing.— Elsdon and Evers. *(Analyst,* XXXVII, 173) CO_2 in the distillates interferes with the Nessler indication to a very appreciable extent. It is recommended first to add a known amount of H_2SO_4 and distil out CO_2, the distillate being of course rejected, then to add enough NaOH to neutralize the H_2SO_4 added; then a little Na_2CO_3 and distil in the usual manner.

Separating Phospho Molybdate from Silico Molybdate.— Melikov. *(C. Rend.,* CLIII, 1478). By using a solution made up of equal volumes of 30% H_2O_2 and 8% solution of $(NH_4)_2MoO_4$ in HNO_3, the phospho compound was completely dissolved, whereas the silico compound was insoluble.

Sulfur in Insoluble Sulfides.— St. Warunis. *(Ber.,* XLV, 869) Mix 0.5 gm. with a mixture of 4 parts dry Na_2CO_3 and 3 parts CuO, in a porcelain crucible. Cover with a layer of the mixture, and heat slowly to the full heat of a Bunsen burner; maintain this heat for 2 hours, stirring frequently. Cool, leach out with water; boil with Na_2CO_3 solution, filter, acidify with HCl, evaporate to separate SiO_2, and in the solution determine SO_3 by $BaCl_2$ as usual. The CuO is made to serve as a carrier of O to the S in this manner.

Standardizing Acidimetric Solutions.— Morey *(J. Am. Chem. Soc.,* XXXIV, 1027) Benzoic acid, C_6H_5COOH, was found to have many advantages. Its use was suggested in 1903 by Wagner. (Fifth Internat. Cong. App. Chem.) The pure, re-sublimed acid is inconveniently bulky, but that objection is easily removed by melting in a platinum dish, placed in an oven at 140°, and pouring into a test tube. When cold, this gives a stick from which the amounts required may be broken off. In this form it may be kept indefinitely in a glass-stoppered bottle, and used without preliminary drying. The author placed 1 gm. of the acid in a 300 c.c. flask which had been swept free from CO_2. Added 20 c.c. alcohol, and stoppered the flask until solution occurred. Added 3 drops

of 1% phenolphthalein solution, and titrated with N/10 alkali or $Ba(OH)_2$, a current of air free from CO_2 being bubbled through the solution during the titration. The end point chosen was that of a 7% conversion of the indicator *(Vid.* Noyes, *J. Am. Chem. Soc.,* XXXII, 857). The effect of the alcohol was determined by use of a blank test. The results compared favorably with those by other methods.

Carbon Dioxide.— Brubaker. *(J. Ind. Eng. Chem.,* IV, 599) The flask in which the material is treated with HCl is provided with a 2-hole stopper, one carrying a stop-cock funnel tube, the other a tube connecting with a Liebig condenser. The delivery tube of the condenser passes through a hole in the stopper of the receiver flask which has a capacity of 100 c.c., and a mark at the 100-c.c. level. Through another hole of the receiver stopper passes the stem of a broken-off 10-c.c. pipette. The bulb of the pipette is partly filled with glass beads, and has a copper spiral or other device to prevent them from falling out, the bulb being pushed down nearly to the bottom of the receiver. 8 c.c. of strong KOH solution is poured in through the stem of the pipette, which moistens the the beads, and spreads over the bottom of the receiver. When connected up, all gases coming from the condenser must escape by forcing some solution up among the beads, and finding exit through the stem. A thorough contact is thus assured.

A convenient amount of material is weighed out in the generating flask, and after connecting up, the necessary amount of HCl is run in through the stop-cock funnel tube. When the effervescence slackens, heat is applied until the solution boils for 5 min. The receiver is then disconnected, the bead pipette repeatedly rinsed into the flask, finally withdrawn, and the solution diluted to the mark. After mixing well, 25-c.c. lots are taken out for titration with phenolphthalein indicator. The end point must be approached with care, as the disappearance of the red color is rather slow. With baking powders, which are apt to froth over, especially on heating with water, the use of alcohol of 25 to 30% instead of water, will be more satisfactory.

Nitric acid in presence of Nitrous.— Sen and Dey. *(Zts. Auorg. Chem.,* LXXIV, 52) The authors find that hydrazine completely decomposes HNO_2 but does not affect HNO_3. After treatment with N_2H_4 to destroy HNO_2 the diphenylamine test can be applied to determine the presence of HNO_3.

Magnesia — Thermochemical Method.— Fortini. *(Chem. Ztg.,* XXXVI, 270.) An apparatus is arranged as in the Maumené test or others, so that the change of temperature of a solution can be observed. Place 0.5 to 1 gm. of commercial magnesium carbonate, or the asbestos mixture, in the flask, and add 50 c.c. of a 1:1 dilution of HCl. The temperature of the acid must be previously noted, and after mixture any rise of temperature is observed. The reaction $MgO + 2HCl = MgCl_2 + H_2O$ liberates heat, whereas $MgCO_3 + 2HCl = MgCl_2 + CO_2 + H_2O$ affords none. A table has been prepared showing the proportions of MgO corresponding to the rise of temperature noted.

Kaolin — Effecting solution.— Ladd. *(Min. and Eng. World,* June 29, 1912, p. 1350) After heating the dried sample at the full heat of a Bunsen burner flame for 25 min., the mineral is digested in conc. HCl for 2 hours, when all kaolin will have been dissolved. The usual methods for separation of the constituents may then be applied.

Potassium iodate.— Myers. *(Proc. Chem. Soc.,* XXVIII, 99) At ordinary temperatures KIO_3 and $H_2C_2O_4$ react very slowly, but when warmed to 80°C. the reaction is vigorous, and once started will continue with evolution of CO_2 and I. A weighed amount of the KIO_3 with an excess of $H_2C_2O_4$ can be placed in a flask fitted with arrangement for passing steam through, and the I evolved can be conducted into KI solution cooled with ice, in which it can eventually be titrated by standard $Na_2S_2O_3$. KNO_3, when present, gives slightly high results. K_2SO_4 and K_2CrO_4 have no effect. KCl prevents the reaction. $KClO_3$ has the same effect, but CO_2 is evolved. $KBrO_3$ reacts at 30°C. giving Br and CO_2. If allowed to act for some time, the whole of the Br will be given off, and subsequent heating to 80° will cause evolution of the I as before mentioned.

Tungstates and Molybdates.— Kafka. *(Zts. Anal. Chem.,* LI, 482) To the neutral solution add 1 drop of saturated solution of $HgNO_3$, 1 c.c. or more of conc. HCl and excess of KI. Shake until the green HgI first formed redissolves. A blue color shows at once if moderate amounts of WO_3 or MO_3 are present. If in small amount the color develops slowly. 0.2 mgm. Na_2WO_4 will give a distinct reaction. Adding a little KCNS gives a red coloration if Mo is present, even when no perceptible blue coloration appeared in the first instance.

Alkaline Bicarbonate in presence of Carbonate.— Haslam. *(J. Am. Chem. Soc.,* XXXIV, 822) Dissolve the substance in water which has been previously boiled to expel CO_2. Add $CaCl_2$ in excess, let stand 4 or 5 min., and filter. To the filtrate add a few drops of NH_4OH. If much bicarbonate is present, a precipitate will form in about half a minute. If but little is there, 8 to 10 min. may elapse before the precipitate forms. 0.1% $NaHCO_3$ can be thus detected.

Perchlorate determination.— Lamb and Marden. *(J. Am. Chem. Soc.,* XXXIV, 812) Fusion with different reagents, followed by determination as AgCl, is the general plan of all of the methods, but great variations were found in using the different fluxes proposed. In most cases the results proved too low, and on conducting the fusion in a combustion tube, it was found that there was some loss by volatilization. The method found to be satisfactory was to weigh out the perchlorate in a thin (Jena) test tube of 25 to 30 c.c. capacity and then insert two 15-mm. asbestos plugs, one at 50 mm. the other at 95 mm. from the bottom of the tube. The tube was then clamped in a horizontal position and a gentle heat applied. When effervescence ceased, the heat was increased to the point of fusion of the chloride. Then on cooling, and leaching out with H_2O, precipitation by $AgNO_3$ with the usual precautions gave correct results.

Chlorous Acid.— Laseque. *(Bull. Soc. Chem.,* XI, 884) In a solution containing no free alkali $Pb(NO_3)_2$ in excess precipitates $HClO_2$ completely. $Pb(ClO_2)_2$ consists of bright yellow scales, soluble to the extent of 0.07 in water, but practically insoluble in 80% alcohol. When heated slowly to near 100° it changes without loss of weight to a mixture of $Pb(ClO_3)_2$ and $PbCl_2$; heated quickly it gives $PbCl_2$ and O. If the material is alkaline, it should be treated in solution with $Mg(NO_3)_2$, the $Mg(OH)_2$ or $MgCO_3$ allowed to settle, and an aliquot portion of the clear solution taken. After adding an excess of $Pb(NO_3)_2$ add 6 vols. alcohol of 85%, and allow to stand for an hour. Filter and wash with alcohol on a weighed filter, dry over conc. H_2SO_4 and weigh. The other oxygen acids of Cl are not precipitated.

Cyanogen and Hydrogen Cyanide.— Rhodes. *(J. Ind. Eng. Chem.,* IV, 652) HCN passed into acidified $AgNO_3$ forms AgCN. CN will pass through the $AgNO_3$ solution without change, but when passed into KOH solution it forms KCN and KCNO in equi-molecular proportions. The gases to be analyzed are passed through a train of four absorbing flasks, the first two containing acidified $AgNO_3$ solution in known amount, the last two containing KOH solution. After passing the gases, a current of air is drawn through the train. From the solutions of the first two flasks, the AgCN is filtered, and in the filtrate and washings the amount of surplus Ag is determined by titration with standard NH_4CNS. This gives HCN. To the united contents of flasks 3 and 4, a known amount of standard $AgNO_3$ solution is added, then enough HNO_3 to acidify; the AgCN is filtered off and the surplus Ag determined as before by standard NH_4CNS, which gives the data for calculating CN.

ORES — METALLURGICAL (NON-FERROUS) PRODUCTS.

Copper-arsenic group and its separation — Qualitative. Hinds. *(J. Am. Chem. Soc.,* XXXIV, 811) The principles involved are (1.) As^{V} is readily precipitated by H_2S from an HCl solution 2N or over. To separate Cd, Sb and Sn the concentration must be under N/2HCl. To hold in solution the metals of $(NH_4)_2S$ group, the concentration must be over N/8 HCl. (2.) The As lost by boiling an HCl solution depends on amount present and on concentration of the acid. Boiling N/HCl down to one-half loses very little As. (3.) As, Sb and Sn^{IV} sulfides dissolve easily in colorless $(NH_4)_2S$. Sn^{II} needs to be oxidized by boiling with HNO_3 to effect a separation. (4.) CuS is only slightly soluble in colorless $(NH_4)_2S$.

To effect a separation, take say 45 c.c., add HCl to make it N/ in HCl (about 5 c.c. of ordinary conc. HCl) and a few drops of HNO_3. Boil down in an Erlenmeyer to half its bulk. Pass H_2S rapidly, heat and shake. When no more precipitate forms add H_2O (80 c.c.) to bring the solution to N/2 or below. Continue passing H_2S until the liquid is cold. Then filter and wash. Transfer the precipitate to a beaker, cover it with strong NH_4OH and pass a rapid stream of H_2S for a few minutes, warm, shake well, filter and wash. The filtrate and residue are treated in the usual way.

Iron in Lead oxides.— Schaeffer. *(J. Ind. Eng. Chem.,* IV, 659) For PbO and Pb, treat 1 gm. with 15 c.c. H_2O and enough HNO_3 to dissolve. For Pb_3O_4, Pb_2O_3, etc., use less water, and when all Pb, except that as PbO_2, has dissolved, complete the solution by addition of H_2O_2. In either case, boil to complete oxidation of the Fe, cool and just neutralize with NH_4OH, then render acid with a few drops of HNO_3. Pour into a Nessler cylinder, add 15 c.c. of 1:20 NH_4CNS, dilute to 100 c.c. and compare with standards made up to the same volume containing known amounts of Fe, and of course the same amount of NH_4CNS. Standards can be made by dissolving 0.7022 gm. cryst. $Fe(NH_4)_2SO_4$, oxidizing with permanganate after adding H_2SO_4, and diluting to 1 litre. 1 c.c.= 0.0001 gm. Fe.

Manganese — Electrolytically.— Golblum and Gunther. *(C. Rend.,* CLV, 166) The best conditions were found to be: a temperature of 80° C., excess of $(NH_4)_2C_2O_4$; current 2 amp. 3 volts; cathode rotated rapidly (700 times per min.). Practically pure MnO_2 is deposited on the anode, in a homogeneous and adherent coat. The rate of revolution of the cathode was found to have an important influence.

Molybdenum — Electrolytically.— Fischer and Weise. *(Zts. Anal. Chem.,* LI, 537) About 0.2 gm. of alkaline molybdate is dissolved in 120 c.c. H_2O, and acidified with 0.25 c.c. conc. HCl. Electrolyze at 20° C., using rotating PtI anode and a current of 3.5 to 4 amp. for 25 min. or 2.5 amp. for somewhat longer (35 min.). Hydrated Mo_2O_3 is deposited. The amount of free HCl cannot be raised without giving low results, 0.7 to 1 c.c. being absolutely inadmissible. Results are also low if larger amounts of the Mo salt are used.

Antimony in White Metals.— Compagno. *(Atti. R. Acad. Lincei,* XXI, 473) Dissolve 1 gm. alloy in 4 c.c. conc. HCl with 4 c.c. HNO_3 (Gr. 1.2), boil out nitrous fumes, neutralize, add 10 c.c. NaOH (of 43° Be.), 80 c.c. of Na_2S solution (Gr. 1.225), and 6 gm. KCN. Boil 5 min., rinse down the sides of the beaker, and electrolyze over night with a current of 0.1 amp. Wash with H_2O and with alcohol without interrupting the current after all Sb is precipitated.

Lead — Molybdate Titration.— Bannister and McNamara. *(Analyst,* XXXVII, 242) CaO or $CaSO_4$ forms no insoluble compound with molybdate, nor when in solution do they react with $PbSO_4$, but when both Ca and Pb are present in the same solution, titration with $(NH_4)_2MoO_4$ gives high results, the precipitate containing apparently some insoluble PbCa molybdates. Hence in examinations of materials containing Ca, that element must be removed before using the molybdate titration method.

Nickel in Alloys.— Parr and Lindgren. *(Trans. Am. Brass Founders Assoc.,* V, 120) The Ni is obtained as the dimethylglyoxime compound. After filtering and washing, the precipitate and paper are put into a beaker, a known amount of N/20H_2SO_4 added, and after dilution the precipitate is dissolved by heating. Then titrate back with N/10KOH

taking the first faint yellowish tinge as the end point. The solutions are standardized against pure Ni.

Purification of Mercury.— Forbes. *(C. News,* CVI, 74) Small quantities can be purified by streaming through $HNO_3 + HgNO_3$. Larger quantities may be treated by passing air through, and afterward shaking up with powdered charcoal which has been allowed to absorb O. The charcoal will rise to the surface carrying a scum of oxides with it.

Tin — Volumetric.— Patrick and Wilsnack. *(J. Ind. Eng. Chem.,* IV, 597) The Sn is reduced by the combined action of Fe and Sb, and then titrated with standard I solution, the operations being all conducted in a flask through which is steadily passed a current of CO_2. A 500-c.c. Jena Erlenmeyer is used. This is fitted with a 4-hole rubber stopper. Two of these holes serve as inlet and exit for the CO_2, the delivery tube being run nearly to the bottom of the flask. Through a third hole passes a glass rod to the lower end of which is attached by means of Pt wire a spiral of Fe of as pure quality as is obtainable. The rod is intended to slide up and down, that the Fe may be immersed in or drawn out of the solution as may be required. The fourth hole carries a tube through which water for rinsing off the Fe, or the I solution, may be delivered. At least 0.15 gm. Sb should be present, though if present in too large amount (25% or over) it will obscure the end point. With an alloy containing not over 5% Pb or Cu, weigh out enough to contain 0.5 gm. or less of Sn, add Sb if not enough is present, dissolve in 10 c.c. conc. H_2SO_4 by the aid of heat, cool, dilute, add 60 c.c. conc. HCl and 40 c.c. H_2O, insert the stopper with its appendages, lower the Fe spiral into the solution, and boil for 25 min. When reduction is complete, plunge the flask into cold water, and cool down completely before proceeding to titrate. The CO_2 must be kept passing all the time. If too much Pb or Sn are present, the solution is effected with HNO_3 and the whole evaporated to dryness, baked 15 min., then taken up with 1:1 HNO_3 and the solution containing the interfering metals removed, before treating with HCl, reducing, and titrating as above.

Tin — Volumetric.— Banerfee. *(Proc. Chem. Soc.,* XXVIII, 102) The metal is brought into the condition of $SnCl_2$, and is then titrated with N/10 $HgCl_2$ solution. By "spot tests" with KI solution on a porcelain plate the end point can be determined, a yellow color showing when the $HgCl_2$ is in slight excess.

Zinc — Separation of Iron by Ammonia.— DeKoninck. *(Bull. Soc. Chim. Belge,* XXVI, 238) Addition of 5% Mg (as $MgCl_2$) and a sufficient excess of NH_4Cl to prevent precipitation of $Mg(OH)_2$ (5 gm.) gave Fe precipitates free from Zn.

Platinum in small amounts in ores and bullion.— Dewey. *(Bull. Am. Inst. M. Eng.,* No. 64, 439) The button obtained by cupellation contains presumably all the Ag, Au and Pt. Parting with conc. H_2SO_4 leaves Au and Pt to be weighed. Many assayers fuse again with Ag and part with HNO_3. It is assumed that the Pt dissolves in the HNO_3, and the difference in weight is reckoned as Pt. The correctness of such

an assumption is doubtful, and the results are frequently inaccurate. The author treats the solution, from HNO_3 parting, with a limited quantity of H_2S, which precipitates all the Pt and some Ag. The precipitate is filtered off, burned, wrapped in a bit of Pb foil, cupelled again, and parted with H_2SO_4. 1 c.c. of saturated H_2S water diluted with 10 to 20 c.c. of water is the amount advised. It should be added slowly with stirring. Naturally the solution takes on a dark color, but no visible precipitate should separate immediately. It should stand for three or four hours, preferably over night, before filtering. In some cases the button from the H_2SO_4 parting may show the yellow of Au, the result of diffusion of finely divided Au in the solution poured off from the HNO_3 parting.

Gold, Silver and Platinum.— Trenker. *(Metallurgie,* IX, 103) Roll out and cut into small pieces to sample the material; granulation does not give a uniform product. To 0.5 to 1 gm. of the metal add Pb and cupel as usual to remove base metals. Add Ag equivalent to 10 times the weight of Au + Pt and cupel again. Treat the button with conc. H_2SO_4 heated *nearly* to boiling. Boiling dissolves a little Pt. Ag dissolves, except a trace, in about half an hour. Cool, decant, wash three times by decantation with hot H_2O, and then dissolve in the least possible amount of aqua-regia. Evaporate off excess of acid, dilute and filter off trace of AgCl. The solution should now be about 150 c.c. Add 15 c.c. conc. HCl and 1 gm. hydrazine hydrochloride. Let stand at about 20°C. for an hour with occasional stirring. Precipitate is Au. To remove traces of Pt, cupel with 5 to 8 times its weight of Ag, and part with HNO_3. In the filtrate from Au precipitate Pt by boiling and adding NH_4OH.

Lime in presence of Magnesia.— Carron. *(Ann. Chim. Analyt.,* XVII, 127) The method is applicable to magnesites, etc. The solution of chlorides of the two elements is concentrated to 60 or 80 c.c., rendered alkaline by NH_4OH, and 20 c.c. of strong solution of NH_4HSO_3 are added. The mixture is then heated to 90°C. and on the appearance of a crystalline precipitate ($CaSO_3$) 20 c.c. of NH_4OH(22° Be.) is added, with vigorous stirring. Settle for an hour before filtering. Wash with hot H_2O containing a little NH_4OH. The filter and precipitate, when otherwise ready for incineration, are moistened with $(NH_4)_2SO_4$ before igniting and weighing as $CaSO_4$. Mg can be determined in the usual manner in the filtrate.

Fluorine Determination.— Starck and Thorin. *(Zts. Anal. Chem.,* LI, 14) To the solution of the fluoride is added $H_2C_2O_4$ in amount approximately equal to that of the HF present. The mixture is then brought into a condition of slight acidity with acetic, and precipitated by $CaCl_2$. After filtration and washing, the precipitate is dried at 210° and weighed. The weight of CaC_2O_4 is deducted, and the remainder is CaF_2. Experiments have proved that accurate results are thus attainable.

Fluorspar.— Bidtel. *(J. Ind. Eng. Chem.,* IV, 201) The practice

with many is to determine total CaO and CO_2, calculate the latter to $CaCO_3$ and the remaining CaO to CaF_2. Such results are often very incorrect. The method used by the author is: Digest 1 gm. of the sample with 10 c.c. of 10% acetic in a covered beaker on the water bath for 1 hour. Filter, wash four times, ignite at as low a temperature as possible, and weigh. Loss (less 0.0015 gm. for solubility of CaF_2) represents $CaCO_3$. Then add to the mass in the crucible 1 gm. yellow HgO in aqueous emulsion, break up lumps and mix the solids thoroughly. Dry, ignite at dull redness, and weigh. The purpose here is to oxidize sulfides. PbS is changed to $PbSO_4$. Some Fe and Zn sulfides are however unaffected. Expel SiO_2 by adding 2 c.c. HF and evaporating to dryness. Repeat this twice more, using 1 c.c. HF each time. Then add HF again, also some macerated filter paper, and a few drops of NH_4OH. Dry, ignite at low red, cool and weigh. Loss is SiO_2. Then add 2 c.c. HF, and a few drops of HNO_3, heat on the water bath 30 min., and then evaporate to dryness. The residue should be white CaF_2. If not white, add a few drops of HF, and some ammonium acetate solution containing a little citrate, digest 30 min. on the water bath, filter and wash first with some acetate solution, finally with hot water. Ignite and weigh in the same crucible. The residue should be pure white CaF_2. Prove it by adding H_2SO_4, evaporating, etc., and weighing as $CaSO_4$. The acetate solution is made by neutralizing 400 c.c. of 80% acetic with strong NH_4OH, adding 20 gm. citric, and diluting to 1 litre with strong NH_4OH. A correction of 0.0029 gm. should be added to the weight of CaF_2 to allow for losses incident to the treatment described.

IRON — STEEL — FERRO-ALLOYS.

Qualitative for Ferrous Iron.— Slawik. *(Chem. Ztg.,* XXXVI, 54) With tartaric or citric acid and an alcoholic solution of dimethylglyoxime, addition of NH_4OH gives a red coloration, which gradually disappears as the Fe oxidizes, but may be restored by addition of a reducing agent as $SnCl_2$ or Zn.

Copper in Steel.— Linberg. *(Zts. Anal. Chem.,* LI, 19) In the absence of O, Cu is not dissolved by H_2SO_4. By treating in a flask with dil. H_2SO_4 through which a current of CO_2 is passed, all the Fe can be dissolved out, leaving the Cu in the insoluble portion.

Vanadium in Irons and Steels.— Cain and Hostetter. *(J. Ind. Eng. Chem.,* IV, 250) The special features are the complete co-precipitation of V, when a sufficient excess of phosphomolybdate is formed, and the reduction of V in conc. H_2SO_4 solution by H_2O_2. Take of the sample an amount which should contain 0.002 to 0.010 gm. V and treat at first as for P determination, i.e.: Dissolve in HNO_3 (Gr. 1.135), oxidize by excess of strong $KMnO_4$, and reduce excess of MnO_2 by Na_2SO_3, boiling out nitrous fumes, and excess of SO_2 at the proper stages. Then nearly neutralize with NH_4OH, and add Na_2HPO_4 in amount sufficient to give at least 10 times as much P as V in the solution. Bring to boiling heat, and add a sufficient excess of the MoO_3 reagent to pre-

cipitate all the P. agitate for a few minutes, and let stand, when the precipitate should settle rapidly. Decant through an asbestos filter and wash three times by decantion with hot $(NH_4)_2SO_4$ solution (25 c.c. conc. H_2SO_4 and 15 c.c. NH_4OH Gr. 0.90 in 1 litre). Dissolve in conc. H_2SO_4 5 to 8 c.c. for each 0.01 gm. P, heat in a flask to fumes, cool somewhat and add H_2O_2 solution, a little at a time, until the solution takes on a deep brown color (due to Mo but removed by heating). Heat again to fumes for 4 or 5 min. when the blue of the V will be seen. Cool, dilute with about 5 vols. H_2O, and titrate with N/100$KMnO_4$ at a temperature of 70 to 80°C. The conditions of temperature and acidity must be kept within the prescribed limits.

Ferroboron.— Raulin. *(Mon. Sci.,* [5] 1, 434.) The commercial material may contain 5 to 20% B. According to content, treat 0.1 to 0.5 gm. with 3 or 4 c.c. conc. H_2SO_4 and heat gradually to boiling. Cool, add 20 c.c. methyl alcohol, warm on the water bath and finally distil, receiving the distillate in a 2% NaOH solution. Add 15 c.c. methyl alcohol and redistil into the same receiver. Repeat the distillation four or five times. Evaporate the distillate on the water bath finishing by a short heating over flame. Acidify slightly with HCl (methyl orange) heat quickly to boiling and cool quickly. Add 60 c.c. of a mixture of 2 parts glycerine with 1 part ethyl alcohol, and titrate with NaOH and phenolphthalein indicator.

Ferro-Tungsten.— Fieber. *(Chem. Ztg.,* XXXVI, 334) The sample must be made as fine as possible. Treat 0.5 gm. with 10 to 15 c.c. Br and warm gently. Then add 30 c.c. conc. HCl. If all does not dissolve, add 5 to 10 c.c. Br. When solution has been effected, evaporate off the free Br., add 1 to 2 c.c. conc. HNO_3 and 2 or 3 drops HF. The latter prevents adherence of WO_3 to the beaker. Evaporate to very small bulk, and then take up with 40 c.c. HCl (1:5), boil and settle. Filter on a double filter, wash alternately with hot H_2O and dilute HCl, moisten with solution of NH_4NO_3, ignite and weigh. SiO_2 may be retained as an impurity. Expel by HF and H_2SO_4 and weigh again.

Rarer Metals.

Volumetric for Thorium.— Metzger and Zons. *(J. Ind. Eng. Chem.,* IV, 493) In acetic solution, Th is precipitated quantitatively by $(NH_4)_2MoO_4$, which is not the case with any other of the earths usually associated with it. The precipitate is a pale yellow and is so slimy in character that filtration and washing are practically impossible. For volumetric work, a solution containing approximately 20 gm. $(NH_4)_2$-MoO_4 per litre was used. The end reaction is a "spot test" with a few drops of alcoholic solution of diphenyl carbazide, which gives a pink coloration with excess of MoO_3 that lasts about 15 seconds. The solution of the indicator needs to *stand for at least a fortnight* before using. The titration is conducted at the ordinary temperature. Monazite or similar minerals are decomposed in the usual way by conc. H_2SO_4, and the earths separated as oxalates, and eventually converted

to nitrates. Evaporate the solution on the water bath, add H_2O and evaporate again to dryness; add 20 c.c. glacial acetic, dilute with 300 c.c. H_2O, add 1 gm. $NaC_2H_3O_2$, stir till dissolved, and then titrate as indicated. Experiments showed that the precipitate contains 1 mol. Th to 2 mol. Mo.

Thorium in Monazite, etc.— Rosenheim. (*Chem. Ztg.*, XXXVI, 821) The use of sodium hypophosphate (Na_2PO_3) as precipitant is the distinctive feature here. The mineral is decomposed in the manner usually prescribed: heating 100 gm. with conc. H_2SO_4 for some time at 180 to 200°C., treating with ice cold H_2O and making up to 1 litre. After complete settling, 100 c.c. of the clear solution is to be treated with 50 c.c. conc. HCl and 180 c.c. H_2O, the solution boiled, and a cold sat. sol. of Na_2PO_3 added until there is no further precipitation. Filter hot, and wash with hot H_2O acidified with HCl until the washings give no precipitate with NH_4OH and $H_2C_2O_4$. The precipitate may contain Zr and Ti hypophosphates. Boil paper and all with 50 c.c. conc. H_2SO_4, adding KNO_3 crystals from time to time to destroy the filter paper. About 1 to 2 hours are needed to afford a pale yellow solution, which is evaporated nearly to dryness, then taken up with H_2O and a slight excess of NH_4OH, and boiled. When the suspended solid becomes flocculent, add excess of HCl, boil and filter, and in the acid filtrate separate Th as oxalate in the usual manner.

Rare Earths Separation.— C. James. (*J. Am. Chem. Soc.*, XXXIV, 757) A very comprehensive scheme is given with comments and details.

Yttrium Separation.— Whittemore and James. (*J. Am. Chem. Soc.*, XXXIV, 772) The results of experiments with various reagents are given in detail. The summary is:

(1) Ammonium sebacate affords a quantitative separation of Y from Na.

(2) A double precipitation with the same reagent gives a complete separation from K.

(3) $H_2C_2O_4$ in presence of NH_4Cl effects a perfectly satisfactory separation from Fe, Al, Li and Mn.

Separating Zirconia from Iron and Alumina.— Wunder and Jeanneret. (*Zts. Anal. Chem.*, L, 733) Fuse the mixed oxides with six times their weight of Na_2CO_3. Treat with H_2O until disintegrated; add 1 part Na_2CO_3 to facilitate filtration. Boil a few minutes, filter (hardened filter preferable) and wash. If much Al is present, ignite and fuse again, etc. From the filtrate, precipitate Al by boiling with NH_4NO_3. From the residue on the filter the Fe can be dissolved out with 1:1 HCl leaving ZrO_2 which can be ignited and weighed.

In ferro-zircon the same method may be applied after separating Si. Dissolve by use of HCl and Br, add HNO_3 and boil out Br; evaporate and heat to 110°, take up with dilute HCl and filter off SiO_2; ignite and weigh. Expel Si by HFl and H_2SO_4, and add the residue to the ignited precipitate obtained by addition of NH_4OH to the filtrate from

the SiO_2. Fuse up with Na_2CO_3 and treat as described above. Weiss and Trautmann (*ib.*, LI, 303) find this method untrustworthy.

Vanadium — New Method.— Demorest. (*J. Ind. Eng. Chem.*, IV, 249) The method depends on the selective oxidation of $FeSO_4$ in presence of $V_2O_2(SO_4)_2$ by MnO_2. In a 500-c.c. flask dissolve 2 gm. of the iron or steel in 30 c.c. H_2O and 12 c.c. conc. H_2SO_4; add 1 c.c. conc. HNO_3 and boil out nitrous fumes. Add 30 c.c. H_2O and strong $KMnO_4$ solution (15 gm. per litre) to oxidize the C. Enough $KMnO_4$ must be added to show an excess of MnO_2 flocks in boiling. Add $FeSO_4$ to reduce all reducible compounds, and boil. Dilute to 250 c.c. and add N/10$KMnO_4$ until the solution is slightly pink. Cool, and then cautiously add $FeSO_4$ solution (0.01 gm. Fe per litre) until there is a slight excess. Add 1 gm. c.p. MnO_2 in powder, and shake to oxidize the Fe; 4 to 6 min. will probably be necessary. In a special note, p. 256, a difference in action was observed with MnO_2 of different degrees of fineness. Begin to test after 2 min., and at 1 min. intervals thereafter. When a drop of the solution on a porcelain plate fails to show an *immediate* blue color with a drop of ferricyanide the Fe is oxidized. A prussian blue color after the lapse of a few minutes has no significance. Filter through asbestos, and titrate the filtrate with standard $KMnO_4$. Add 1 c.c. in excess, allow to stand 1 min., and then titrate back the excess with standard Na_3AsO_3 solution. A blank should be run on a V-free steel, and deduction made accordingly. The solution can be again reduced with $FeSO_4$, re-oxidized with MnO_2, etc., if it is desired to repeat the test.

Industrial Materials.

Iodides — Direct Titration.— Turrentine. (*J. Ind. Eng. Chem.*, IV, 435) In determining iodide in kelps, etc., a satisfactory and rapid method was found to be as follows: To a convenient quantity of the solution in a flask was added 15 c.c. H_2SO_4 (1:1 by vol.) and 15 c.c. CCl_4 (specially purified). Standard $KMnO_4$ was then run in slowly, with frequent shaking to cause the CCl_4 to take up the I set free. As usual, the end reaction is the pink coloration of the aqueous layer by excess of $KMnO_4$, which should persist for 1 min. The $KMnO_4$ was standardized by a solution containing 1 gm. KI in 1 litre. The reaction is slow toward the end. A blank test (omitting the iodide) indicates that a small correction must be made for oxidizable substances in the CCl_4. With the materials used by the author this amounted to 0.2 c.c.

Iodine in Sea-weeds, etc.— Auger. (*Bull. Soc. Chem.*, [4] XI, 615) To the solution containing approximately 0.05 gm. I add 5 c.c. of 36° Be. NaOH solution, and heat on the water bath. Add little by little conc. solution of $KMnO_4$ in slight excess, as shown by he color; heat 5 min., dilute to about 250 c.c., acidify with acetic and then add H_2O_2 sufficient to remove MnO_2. Add dilute $KMnO_4$ to destroy the excess until a brown rose tint appears, then dilute H_2O_2 is added cautiously until the brown tint disappears. At this point add 1 gm. KI and 5 c.c. HCl, and titrate with standard $Na_2S_2O_3$.

Petroleum in Paint-oils, etc.— Pollard. (*Analyst*, XXXVII, 247) Fuse about 10 gm. NaOH in a Ni crucible. When just melted, add about 5 c.c. of the oil or paint, and stir in with an iron rod. Cool by standing in cold H_2O, and then stir in 50 c.c. petroleum ether. Under these conditions, the soap, etc., forms a powder which settles to the bottom, and the petroleum ether may be poured off through a filter. Boil off the petroleum ether. The residue may be petroleum, or rosin oil plus a small amount of unsaponifiable matter from the linseed oil. Add 3 c.c. HNO_3 and boil. If anything more than mere traces of oil remain, the article contains petroleum oil.

The lighter petroleum oils, which would be volatilized at the temperature of fused NaOH, may be detected by distilling in a current of steam.

Linseed Oil.— Leversedge and Elsdon. (*J. S. C. I.*, XXXI, 207) Finely powdered litharge is dried for some time in an incubator at 20 to 22°C. About 10 gm. is then weighed out in a flat-bottomed, German silver dish, 0.7 to 0.9 gm. of the oil is added, and after weighing, 5 c.c. methylated ether. By carefully rocking the dish, the mixture is made uniform, and spread evenly over the bottom of the dish. This is then kept in the incubator at 21°C. and weighed from day to day. Raw linseed oil gains 15 to 18% in 2 to 3 days, and after that loses a little. Boiled linseed gains 12 to 14%, usually in 1 day, after which there is a loss. Non-drying oils gain little or none at first, but continue to gain for weeks. Wilson and Heaven *ib.* p. 565 describe a method based on the measurement of the volume of O absorbed.

FOODS — SANITATION.

Nitrates in Waters.— Knight. (*Chem. World*, I, 247) According to requirements, 10 to 50 c.c. of the water is evaporated on the water bath to a syrup, after addition of 1 c.c. of H_2SO_4 containing 1% salicylic acid. Dilute to 10 c.c. and add NH_4OH, or NaOH. Color comparisons can be made with solutions of KNO_3 or other nitrate of known strength. It is stated that chlorides do not interfere. The process is on the lines of the phenol sulfuric method, but the advantage claimed is that it dispenses with the uncertainties connected with the preparation and keeping of the phenol sulfuric reagent.

Sulfates in Water — Modified Winkler Method.— Brubaker. (*J. Am. Chem. Soc.*, XXXIV, 284) Measure 150 c.c. of the sample into an Erlenmeyer. Add 10 drops conc. HCl, and sprinkle in 0.1 to 0.2 gm. pure $BaCrO_4$. Bring quickly to a boil. Then cool, and add 5 gm. $NaC_2H_3O_2$. Filter, transfer 100 c.c. of the filtrate to a colorimeter cylinder, and make just alkaline with NaOH. The standard solution for comparison should be made up a little stronger, and diluted to 100 c.c. after neutralizing. A blank determination must also be made, to obtain the correction for the solubility of the $BaCrO_4$. Of course the CrO_3 is actually determined, which is molecularly proportionate to the SO_3 present.

Antimony in Enamels.— Rickmann. (*Zts. Angew. Chem.*, XXV,

1518) Metantimonates are not poisonous, whereas salts in which the Sb plays the part of a base, are poisonous. Boiling the enamel 30 min. with 4% acetic or 2% tartaric will extract the poisonous form, which may be titrated with permanganate.

Dust in Air.— Collection for Examination.— Johnston. *(J. Chem. Met. Min. S. Africa,* XII, 442) A known volume of the air (50 litres or more) is drawn through a 2-in. layer of dampened, coarsely crushed sugar in a separator funnel. A rate of 200 litres in 30 min. is not regarded as too rapid. The sugar may then be dissolved off, and the dust weighed or otherwise examined. The finer particles of sugar should be sieved out before use. The use of a blank test in some cases may be necessary.

Test for Acetylene.— Llorens. *(Anales. Soc. espan. fis. quim.,* X, 139) A solution of $CuSO_4$ is saturated with NaCl, and $NaHSO_3$ solution is added drop by drop, until the tint is pale yellow. If too much $NaHSO_3$ has been used, add a few drops of NH_4OH, and again add $NaHSO_4$ if a precipitate or a blue color was produced. Paper saturated with this solution gives the characteristic red coloration when in contact with C_2H_2.

SUMMER ACTIVITIES

CAMP COLUMBIA.

The summer school of surveying at Camp Columbia, Morris, Conn., opened on June 1, and closed on September 14. The session was marked by a rather low attendance, as is shown in the table following, but from an educational standpoint was satisfactory inasmuch as only 23 men out of a total of 261 failed to complete their courses. This good record was probably due to the excellent weather prevailing especially during the latter part of the summer and is in marked contrast to last summer's work, when a large number of freshmen reporting in the third division, which is limited in time to the date set for closing camp, failed to complete their work on account of rainy weather.

SUMMARY OF LAST FOUR YEARS

	1909	1910	1911	1912
Total number of different students	302	309	280	261
Maximum attendance, omitting last week	151	181	132	116
Minimum attendance " " "	75	112	73	51
Average attendance " " "	122	135	106	100
Students taking Course 15	179	199	167	176
" " Course 25	51	33	49	33
" " Course 27	73	69	58	42
" " Course 26	30	35	22	37
" " Course 28	61	48	42	28
" " Course 71	28	37	26	38
" " Geodesy	30	35	22	35
Special students in Course 15	2	0	3	0
" " " " 25-27	1	0	2	0
Failing to complete Course 15	18	47	52	19
" " " Course 25	7	7	12	3
" " " Course 27	6	5	20	1

The record of weather conditions shows that in a total of 106 days, 67 were clear, 25 cloudy, 10 rainy, and 4 showery. Maximum temperature recorded was 93° on July 9, and minimum was 43° on June 8. The average daily mean temperature has seldom varied more than a degree from 67° and for the past summer was 67.7°.

In regard to the surveying work during the session, only one change in the routine was made. On the suggestion of Professor W. S. Williams of the University of Wisconsin, who was with us last year, the azimuth traverse and farm surveys of Course 15, the Freshman course, have been combined into one survey. The farm survey has formerly been made with a compass and band chain. It is now general practice to make surveys of this kind with a transit; and as it was thought that extra work with a transit would be more beneficial to those students who reported at Camp for Course 15 only, a small amount of compass work is still required preliminary to the actual survey, which is now made by azimuth traverse with a transit, checking azimuths with bearings read by the compass on the transit.

Due to the fact that Professor S. A. Mitchell, of the Department of

Astronomy, who has hitherto handled the field work in geodesy, had been granted a leave of absence to take up the work of Professor Frost, Director of Yerkes Observatory at Williams Bay, Wisconsin, during the latter's absence, it became necessary to engage someone else to carry it on last summer. On the recommndation of C. H. Tittman, Superintendent of the United States Coast and Geodetic Survey, William Bowie, Inspector of Geodetic Work and Chief of the Computing Division of that survey, had charge of this work. Aside from the great help Mr. Bowie was able to give us in bringing into our geodetic work the present practice of the government survey he was also able through the coöperation of the Western Union Telegraph Company and Professor Hill of the United States Naval Observatory, Washington, D. C., to make and to demonstrate to the students in geodesy an accurate determination of longitude. This work involved the running of a temporary loop from the Western Union line at Bantam to Camp, a distance of three miles, obtaining a clear wire from the Observatory at Camp to the Observatory at Washington, and the telegraphic exchange of time signals between the two observatories on four evenings. The exact time of the signals exchanged was determined at Washington by a Roeffler clock, a remarkable instrument, which is kept in a vault under constant temperature and pressure, is operated by electricity, and has a very small and uniform rate. An ordinary break-circuit chronometer was used at Camp, and in order to determine its rate a series of star transits was observed just before and just after the exchange of signals. For this purpose a regular longitude set was loaned by the government and consisted of a transit instrument with self registering eye-piece, chronometer, chronograph, sounders, relays, batteries, etc. This same outfit had been used in running the international boundary between Canada and Alaska, and was sent from Camp to Colorado, where it was used for longitude determination at five points between Denver and the Canadian boundary. The Fauth instrument, which is used by the students at Camp in ordinary transit work, is of the same type except that the eye-piece is not self registering.

The instructing force at Camp changed at several times during the summer. During June R. W. Briggs, C.E. '11, formerly Assistant in the Department of Civil Engineering, and at present Instructor in Civil Engineering at Trinity College, Durham, N. C., had charge of the topographic and plane-table surveys; W. D. Tripper, C.E. '11, was responsible for the work in differential and profile levelling, and the city surveys; W. H. Shearman, E.M. '10, had supervision of the repetition and mine claim work, and the pacing and farm surveys were under the direction of A. D. Duffie and W. W. Heinbruch, members of the Senior class in civil engineering. R. E. Goodwin, Yale, C.E. '12, took up the latter work early in July and carried it through the rest of the summer. Mr. Goodwin is now Assistant in the Department of Civil Engineering.

During the five weeks of Geodesy, Mr. Briggs was transferred to the geodetic work which was under Mr. Bowie's direction, and Mr. Bowie was also assisted by Wm. M. Smith, Ph.D. '11, Assistant Professor of

Mathematics, University of Oregon and, L. D. Nosworthy, C.E. '09, who is at present taking up some of the work of J. S. Macgregor, in our testing laboratory, during the latter's year of absence. J. I. Moore, E.M. '12, assisted in the levelling work during the last part of the session. The writer had charge of the general supervision of the work at Camp under the direction of Prof. Earl B. Lovell, and also attended to the solar work and the hydrographic survey.

Apart from the serious side of Camp life we are able to report gratifying results in the various athletic, theatrical and social efforts of the school. The annual regatta of the Bantam Lake Regatta Association turned out to be almost entirely a Columbia affair. The faculty won the senior canoe race, skiff race and also the sailing race while the swimming honors were carried off by J. W. Pulleyn, E.M. '14. A trip was also made to a regatta at Lake Quassapaug, resulting in victory in the swimming and canoe tilting and a second in the only other open event—the double canoe race. Under the captaincy of J. P. Maloy, C.E. '13, the baseball game with Litchfield was won by a score of 8-4. The annual railroad dinner in the evening, a sort of combined celebration of the game and the finishing of the work at Camp for the men taking railroad surveying, proved a very joyful occasion, in which we all took part and each did as requested in the way of producing amusement for the camp. Messrs. Downing, Hadsell and Beatty acted as the "Strong Arm Squad" to see that the desires of the diners were carried out. The Camp band performed on this and many other evenings and a show given under the management of L. H. Seelye, Y. M. C. A. Secretary, was greatly appreciated by the residents of Bantam and Morris.

We were pleased to have a visit last summer from Dean Goetze, who was accompanied by B. B. Lawrence, E.M. '78, Alumni Trustee, and John B. Pine, clerk of the Board of Trustees. This was Mr. Pine's first visit to Camp and we were glad to have the opportunity to show him the fine plant that the University has at Morris. Among other visitors were Prof. Ira O. Baker, of the University of Illinois; C. B. Stanton of the Carnegie Institute of Technology; A. S. Dwight, E.M. '85; H. P. Bellinger, C.E. '87; O. K. Hand, '86; W. T. Derleth, C.E. '04; F. W. Hehre, E.E. '08, of the Department of Electrical Engineering and G. L. Burr, C.E. '12. Prof. Wm. H. Burr visited and inspected Camp on Sept. 6, but his trip was cut rather short by an accident on the Barge Canal requiring his leaving for Rochester on the evening train.

The session for the summer of 1913 will open May 31 and continue until September 13. We shall be pleased to welcome any member of the faculty or graduate of the University to Camp during this period and can promise a pleasant week end at the home of one of Columbia's many interesting summer activities. J. K. F.

DEPARTMENT OF GEOLOGY.

The Department of Geology organized a field trip to Hazleton, Pa., the first week in June. This is regularly required work for the third year students in mining engineering, but is often taken by advanced stu-

dents in geology, and by students from other colleges also. About 50 men spent the week studying the geology of this anthracite district, and made a reconnoissance geologic map of about 250 square miles, reaching from Wilkesbarre on the north to Mauch Chunk on the south. The whole staff of instructors of the department was in the field, and Dr. E. O. Hovey, of the American Museum of Natural History, assisted in the management of field parties.

Several courses of regular instruction were given by the Department of Geology in the Summer session of the University. Prof. Grabau and Mr. Fettke of the regular staff conducted independent classes covering general elementary geology, advanced general geology, stratigraphy and petrography. A field excursion lasting two weeks was conducted at the close of the Summer session, in which a number of advanced students joined. The notable feature of the Summer classes in geology was the large number of students engaged in advanced work.

C. P. BERKEY.

METALLURGICAL FIELD WORK.

The class in metallurgical field work assembled in New York on June 10, sixteen men reporting for the first stage of the course.

The first week was spent in visiting the works of the U. S. Metals Refining Co. at Chrome, N. J., and of the Balbach Smelting & Refining Co. in Newark, N. J. Unfortunately, owing to a strike at the plant of the American Smelting & Refining Co. at Maurer, N. J., this large establishment could not be seen, but at the other plants named, the students, under the direction of Prof. Kern, studied the operation of electrolytic refining of pig copper. Many improvements in this work have been made at the Chrome plant and special attention was given to a study of these improvements.

At the Balbach works, the class investigated the operation of refining lead bullion, separating the gold and silver and impurities from the lead in bullion, by the Parkes process, and the subsequent recovery of the gold and silver in the shape of doré.

Next, the class, which now numbered twelve men, visited the iron and steel works at Pittsburg, beginning this work on June 17, under the direction of Prof. Campbell.

At the Edgar Thompson plant the gas engine department was of special interest, and the work of the gas engine units on a large scale was studied carefully. At the Homestead plant the class was fortunate in seeing the casting of a very large armor-plate ingot, weighing in the neighborhood of 180 tons, an operation which is seldom seen by visitors.

The Duquesne plant of the Carnegie Steel Co. was also visited, and in connection with these visits the courtesy shown by Mr. Hugh P. Tiemann, for passes and advice as to special points of interest, was greatly appreciated.

At the Crescent plant of the Crucible Steel Co., the tungsten reduction department was shown to the students; and at the Park plant of this same company the men were met and shown around by Mr. Page, an Early Eighty, who is manager, and Comstock, Met. E. '10. The manu-

facture of high-speed steels was of special interest. At the Pressed Steel Car Co., cars in all stages of building were seen as well as the malleable department and the car-wheel casting works. Every attention possible was shown the students by this company and an excellent lunch was provided.

Through the invitation of Dr. Holmes, the Bureau of Mines was visited where explosive tests for mine explosives were shown, also the mine rescue car and a demonstration of the rescuing apparatus of the Government.

Short visits were also made to the Schoenburger plant of the American Steel and Wire Co., the National plant of the National Tube Co., the McKeesport Tinplate Works, and the Jones & Laughlin Southside Works, simply for the purpose of showing the students special work which was not seen elsewhere.

On July 1, the class arrived at Gary and visited the Indiana Steel Co., where Clarence Mapes, Met. E. '10, obtained special privileges to show the men around. This plant is the largest and most modern of those visited, and the gas engine department and power plant, together with the electrically driven rail and plate mills, called for special attention. In the testing laboratories, work in connection with testing steel rails was viewed with interest.

On July 2, the class was met by Prof. Walker, at Chicago, who took charge of the students who desired to go the far west (six in number) for the balance of the trip. The first point visited was the large lead refining works at Omaha, one of the refining plants of the American Smelting & Refining Co. This plant, which formerly treated ores, mainly of lead, from all over the country, is now practically only a lead refinery and is the largest of its kind in the world. It refines approximately 10,000 to 11,000 tons of lead bullion a month.

Leaving Omaha the party travelled across the plains to Denver. Here the Globe plant of the American Smelting & Refining Co., was visited and the operation of smelting lead ores on a large scale was carefully studied. Mr. Roeser, E.M. '84, the Superintendent of the plant very kindly explained all the details in person.

The next stopping point was Colorado Springs, in order that the cyanide plants at Colorado City might be inspected. Four days were spent in this work during which time the old Portland mill, which has been changed from a chlorination plant to a cyanide mill, and the Golden Cycle mill, which is one of the largest cyanide plants in the country, were seen. These plants, taken together, show the different methods of treating gold ore by the cyanide process, and as practically all the ore treated comes from Cripple Creek, a preliminary roasting operation is necessary. A day was spent in Cripple Creek to give the students an idea of what this mining camp was like.

At Pueblo, the works of the United States Zinc Co. were visited, and a careful study was made of the operations in smelting zinc ore at this place.

The class then journeyed across the Rocky Mountains to Salt Lake

City, and spent the last week of the trip in visiting the various plants in this great metallurgical center. Those visited were the Tooele plant of the International Smelting Co., the Garfield plant of the American Smelters Securities Co., the Midvale plant of the United States Mining & Smelting Co., and the mining operations of the Utah Copper Co. at Bingham Cañon.

At the smelting plants mentioned the operation of smelting lead and copper ores on a large scale was carefully studied and the work of the basic converter process proved to be of great interest. At the Midvale plant the recovery of arsenic from the baghouse fumes was carefully explained to the students and it was shown how a product which was formerly wasted, and which was at the same time harmful to vegetation, was recovered at a profit. The visit to Bingham Cañon was for the purpose of giving the students an idea of the great magnitude of the operations carried on at this point. Both the steam shovel work at the Utah Copper Co. and the underground work of the Boston Consolidated Co. were inspected. While in Salt Lake City the students met a number of former graduates, among whom might be mentioned, Strobel, E.M. '11, Warner, Met. E. '12, Corsa, E.M. '11 and others.

On July 21, the field work ended, and the men left shortly after for the East, feeling that they had not only learned a great deal about the various metallurgical operations they had been hearing about in the classroom, but also that they had seen these operations carried on on such a large scale that they had an adequate idea of the work done in this line in the United States and of its great magnitude. At all plants visited the students made notes of the operations and sketches of the metallurgical appliances in notebooks designed for that purpose. In addition to this each student makes a detailed report on some one of the various plants visited.

After finishing with the class, Prof. Walker left for the Pacific Coast where he inspected other plants and then made a trip to Alaska.

A. L. W.

MINING TRIPS

During the past summer 32 mining students have been at work in the field, carrying on the regular note-taking and sketching of which a minimum period of six weeks is required. Besides these, three students have been given full credit for the course in consideration of a number of months' work done in the employment of mining companies, and two others partial credit; total, 37 finishing the course.

As has been the practice for some years past, the class was divided into squads of from two to six men and assigned to mines at which arrangements had previously been made. Before they left the city, oral instructions were given to the class, in addition to which each student was provided with a printed detailed summary of the work to be done.

The squad work was arranged as follows: Beehler, Lunn, Prochazka, Trischka, and Schmidt, at the Cresson gold mine, Cripple Creek, Colo.;

Chow, Hess, Hubbard, Morrill, Rugen and Wise, at the mines of the Tennessee Copper Co., Copperhill, Tenn. (Browning worked at the same mine.) Burroughs, Officer and Tackmann, Penn Iron Mining Co., Vulcan, Mich. Hoyt, Moore and Patchell, St. Lawrence Pyrites Co., Stellaville, N. Y. Caruthers and Hickey at the Woodward and other anthracite collieries near Wilkes-Barre, Pa. Manes and Rade, Cumberland-Ely Copper Mining Co., Nevada. Abrahams, Goldstein and Pineda, at the collieries of the Lehigh Valley Coal Co., near Hazelton, Pa. Richter and Salsbury, collieries of the Delaware & Hudson R. R. Co., near Scranton. Sun, Washington iron mine, Oxford, N. J. Gatch, Isle Royale copper mine, Mich. Claghorn, mines of the Alaska-Mexican Gold Mining Co., Treadwell, Alaska. Suverkrop, Butte, Mont. Grant, Alabama; and Wagner on the engineering staff of the Lehigh Valley Coal Co., Hazelton, Pa. Many of the members of the class exceeded the required six weeks; 11 gave seven weeks to the work; three gave eight weeks, and three about ten weeks each.

The usual mine survey was carried on in the early part of June by the entire class, at a large colliery of the Lehigh Valley Coal Co., Hazelton. This work, occupying one week, was in immediate charge of Prof. Kurtz and Mr. Judd, with five special assistants.

A large proportion of the class did excellent work, both in note taking and sketching. Many of the sets of note-books contain valuable records of speeds of drilling, blasting, tramming, hoisting and other mine operations, together with many costs. Engineering data of this kind are collected only by painstaking, often tedious, attention to details. Such notes are useful to the members of the class, not only as part of their training but will often prove of value in their future field practice.

The thanks of the students and staff of the School of Mines are due to the mine managers and superintendents who have coöperated so cordially in affording the privileges and facilities necessary for carrying on this summer work. Special mention should be made to the kindness of Mr. Richard Roelofs, of the Cresson mine; Mr. R. V. Norris, Consulting Engineer, Susquehanna Coal Co., Mr. A. H. Case, of the Tennessee Copper Co., Mr. Wm. Kelly, of the Penn Iron Co., Messrs. F. T. Rubidge and O. F. Pattberg, of the St. Lawrence Pyrites Co., Mr. Davies, of the Lehigh Valley Coal Co., and Messrs. A. B. Menefee and L. H. Brown, of the Empire Steel and Iron Company.

R. P.

ANNUAL MEETING OF THE ALUMNI ASSOCIATION

The last annual meeting of the alumni association was held in the rooms of the Aldine Club, New York, on the evening of April 26, 1912. Excellent arrangements had been made for the entertainment of a joint meeting with the alumni associations of the other schools after the business meeting, and a large attendance was present. The retiring President, John H. Janeway, presided.

After the minutes of the previous meeting had been read and approved, the result of the ballot for officers for 1912-13 was announced, as follows:

President — Francis M. Simonds.
Vice-President — Wheaton B. Kunhardt.
Treasurer — John S. Douglas.
Secretary — Ralph E. Mayer.
Managers — John R. Brinley, Walter I. Slichter, William Newell, Edward C. Kendall.

The President went on to explain the action of the delegates appointed by the Association to attend the convention called to nominate an Alumni Trustee, which had been held a few days previously. Inasmuch as the trustees nominated by this convention on the two preceding years had been those supported by the delegates of the Science Alumni, it was thought proper on this occasion to refrain from presenting a candidate; the way was thus left open for the nomination of the candidate supported by the College Alumni.

The Secretary then presented the following report:

Members, May 31, 1911		1283
Class of 1911, joining		97
Men of other classes, joining		14
		1394
Dropped for non-payment of dues	109	
Resigned	14	
Deceased	3	
		126
Total membership, April 26, 1912		1268
Classified as follows:		
Honorary members	9	
Active members	1222	
Associate members	37	
		1268

The Treasurer next reported as follows for the period May 31, 1911, to April 26, 1912:

Balance, May 31, 1911	$ 503.10	
Dues received, 1911-12	2,710.10	
Interest on deposits	14.51	
	$3,227.71	
Paid to Alumni Council	$ 359.41	
School of Mines Quarterly Board	1,129.30	
Typewriting and clerical work	147.52	
Printing and postage	182.15	
Columbia University Commons	47.00	
Columbia University	2.00	
Underwood Typewriter Co.	23.00	
Total disbursements	$1,890.38	
Balance, April 26, 1912 *	1,336.33	
	$3,227.71	

On behalf of the Board of Managers, the following report was then submitted:

The Board of Managers held meetings in November, December, January, February and April for the transaction of current business and for the discussion of matters of interest to the members of this Association.

The Board authorized the payment of the balance due on their annual subscription to the Alumni Council for the year 1911-12.

Among the topics coming before the Board, one of prime importance was the devising of some method by which the present activities of the Association may be continued while at the same time keeping the necessary expenditures within the income of the Association.

Closely associated with this is the question as to whether or not the QUARTERLY should be continued. To the end that this question might be settled, a committee was appointed to consider and report to the Association the desirability of continuing the QUARTERLY. The committee has taken steps to put this matter before the whole membership.

A matter which came up for discussion by the Committee on Technical Education was the proposed graduate course in engineering. A very complete report of this committee was presented to the Trustees of the University and was published in the *Alumni News* and distributed to the members of this Association.

The Board authorized the Secretary to make the proper arrangements for this Association to take part in the general reunion of alumni to be held tonight.

The following report was submitted by Arthur L. Walker, as chairman of the Board of Editors of the QUARTERLY:

The result of issuing the QUARTERLY during the past year, we believe, has been beneficial; a number of excellent and valuable papers have been

* Outstanding obligations for which bills have not yet been rendered will materially reduce this balance.

contributed, several of which have been widely copied by the leading technical papers. The several issues made their appearance as promptly as could be expected.

In each issue, besides book reviews, abstracts, personal notes, departmental reports, etc., we published from five to eight technical papers, the subject matter of which may be grouped as follows: Mining, 6; metallurgy, 5; civil engineering, 3; chemistry, 3; geology, 3; mechanical engineering, 4; electrical engineering, 2; general, 1; total, 27 papers.

This shows how we have attempted to cover the several fields in which our readers are interested.

Arthur S. Dwight then presented the following resolution, the outcome of informal debate among a number of alumni present:

RESOLVED, that the President of the Alumni Association of the Schools of Mines, Engineering and Chemistry of Columbia University be requested to appoint a committee from the Association at large to consider carefully the organization of a fitting celebration, in 1914, of the fiftieth anniversary of the founding of the School of Mines, in 1864, and to report its conclusions and recommendations to the Board of Managers of the Association.

The meeting now becoming more informal, the President called upon a number of those present for impromptu speeches, to which call several of the past Presidents of the Association responded.

At this point, the Early 80's fife and drum corps began to make itself heard, and the speeches came to a stop. All present adjourned to a central room where they were joined by the College men, the Lawyers and the Medics, who had been holding meetings of their own in other rooms. Under the jovial chairmanship of Dean Van Amringe, proceedings now began to take on a lively turn. President Butler made a speech in which he paid high tribute to the memory of the late George G. DeWitt, trustee, and then announced the election of James D. Livingston, as alumni member of the Board of Trustees. Mr. Livingston responded to the demand for an address.

The Glee Club now took a hand, alternating its songs with the speeches and other entertainments, all punctuated throughout by the cheerful rapping of bung starters in the rear. Corn-cob pipes and tobacco were also on tap.

The kegs, the plates of salad, and the piles of sandwiches now became the nuclei of animated crowds, which did not disperse until a late hour. This joint meeting was the first of its kind to be held at just this season, but unless the appearance of jollity and good fellowship was wholly simulated, it is highly probable that the experiment will be repeated.

THE FUTURE OF THE QUARTERLY.

The future of the QUARTERLY has been the subject of very earnest consideration for several months, and its discontinuance has been seriously proposed in many quarters. The opposition to its continuation has been based mainly on two grounds: That the QUARTERLY does not meet the needs of its subscribers, and that the cost of its publication is too heavy a drain on the treasury of the Alumni Association.

The first objection raises such a broad question that it can not be fully discussed here. The difficulty is that the interests of the alumni of the Schools of Mines, Engineering and Chemistry are so widely diversified that it would be almost impossible to appease the wants of any one group of graduates by a publication ten times the size of the QUARTERLY. These wants, however, are well supplied by numberless technical papers devoted to special industries, leaving the QUARTERLY to appeal largely to the pride of the Association in maintaining a periodical of its own, now 33 years old. That such pride is measurably justified may be inferred from the wide circulation given to articles reprinted from the QUARTERLY by leading technical papers all over the country. It may be added that the editors have in mind and will put into operation a number of ideas aiming at greater timeliness and wider interest. The statement on a following page will indicate to what extent the editors have succeeded in dividing the available space among the several interests during the past year.

The financial problem is easier. Within recent years the practice has been to divide each $3.00 of annual dues as follows: Support of the QUARTERLY, $1.50; contribution to Alumni Council, $1.00; miscellaneous expenses of the Association, $0.50. The first two obligations have been met punctually and in full, but the Secretary has found it increasingly difficult to carry on the work of his office, including publication of the Alumni List, clerical assistance and postage, on the basis of $0.50 per member. This led to the suggestion that annual dues be raised to $4.50, and a letter ballot presenting this as an alternative to discontinuing the QUARTERLY was sent to all members of the Association in June, 1912. Canvass of

this ballot showed 263 in favor of increasing dues, and 169 in favor of discontinuing the QUARTERLY. Still another suggestion has been offered, that the support of the QUARTERLY be taken over in whole or in part by the University. Negotiations to this effect met with refusal by the University authorities.

From inspection of the balance sheet, which follows, it appears now that the financial condition of the QUARTERLY is not so precarious as had been supposed. After paying all expenses on an undiminished scale during the year 1911-12, the cash surplus increased by the amount of $360. This was due principally to larger income from advertising and subscriptions. For this reason the Board of Editors has decided to recommend that only $1.00 out of each annual due be devoted to the QUARTERLY, instead of $1.50 as heretofore, leaving $1.00 instead of $0.50 for the running expenses of the Association. This is in line with a suggestion made by Secretary Mayer three years ago, and again more recently, but on both occasions without receiving the approval of the Board of Managers. This plan seems to offer a solution of the present difficulty, and in the absence of definite instructions to the contrary from the Board of Managers, the editors have arranged to publish the QUARTERLY for the year 1912-13 as usual.

BOARD OF EDITORS MEETING.

A meeting of the Board of Editors was held on Friday afternoon, Oct. 18, 1912. Messrs. Campbell, Judd, Moses, Peele, Slichter and Walker were present. Professor Moses was elected chairman of the meeting.

The question was at once raised as to whether, under the present unsettled conditions, the QUARTERLY and its Board of Editors really had any existence. The following letter from the Secretary of the Alumni Association was thought to give sufficient warrant for proceeding to business, as though the question of discontinuing the QUARTERLY had never arisen:

October 4, 1912.

PROF. ARTHUR L. WALKER,
Columbia University.

I beg to acknowledge the receipt of your letter of Oct. 2 in reference to the action of the Board of Managers of the Alumni Association on the question of continuing the publication of the QUARTERLY.

The regular meeting of the Board for October was called, but a quorum not being present, no meeting was held.

The letter ballot of June, last, showed that of 432 members voting, 263 were in favor of continuing the QUARTERLY and increasing dues, and 169 were in favor of discontinuing the QUARTERLY. In view of this vote, and keeping in mind by-laws IV and VI, page 222 of the Alumni List for 1910, I do not

see how our Board of Managers can take any action to suspend the publication of the QUARTERLY for the year 1912-13.

At any rate, unless definite instructions to the contrary are sent to me, I will continue to endorse the payment to the SCHOOL OF MINES QUARTERLY of one-half the total receipts of the Alumni Association from annual dues.

R. E. MAYER,
Secretary.

The following report was submitted by the business manager covering the period Nov. 29, 1911, to Oct. 12, 1912:

Receipts:	
Balance from former manager, Nov. 29, 1911	$ 624.44
From Alumni Association	1481.77
From advertisers	862.25
Subscriptions, reprints, etc.	176.48
From library	170.37
	$3315.31

Expenditures:	
Printers	$1499.88
Salary of editor	375.00
Engraving	120.50
Wrappers and miscellaneous stationery	121.58
Addressing wrappers	34.00
Stenographic and clerical work	56.50
Drafting	17.00
Postage	74.08
Express	14.56
Telephone	6.83
Binding 8 volumes	11.20
Total expended	$2331.13
Balance, Oct. 12, 1912	984.18
	$3315.31

Inspection of the above report led to the conclusion that if the income from advertising and miscellaneous sources could be maintained at the present level, it would be possible to pay expenses for the coming year on a grant of less than the customary $1.50 per member of the Alumni Association. The following resolution was therefore introduced, and adopted:

The Board of Editors of the SCHOOL OF MINES QUARTERLY recommend that for the ensuing year the Alumni Association be asked to contribute only $1.00 per member in support of the QUARTERLY, instead of $1.50 as formerly; and if the total receipts of the QUARTERLY for the year 1912-13 cover the expenses for that year, they recommend that the by-laws of the Association be so amended as to make this change permanent.

Professor Walker stated that he wished to be relieved of his duties as managing editor; on motion of Prof. Slichter, duly seconded, it was voted to appoint Edward K. Judd managing editor for the coming year.

Informal discussion then took place concerning matters of editorial policy. It was the opinion of all present that every effort should be made to give future issues of the QUARTERLY a more timely and personal interest; this is to be accomplished by devoting more space to reports of matters occurring at the University, and among the Alumni. Mr. Judd offered the suggestion that the forthcoming issue should contain a review of the discussion that has recently taken place regarding the continuance of the QUARTERLY, to include full financial reports of the Alumni

Association, and of the Board of Editors, and to contain excerpts from letters received from alumni bearing on this subject. The suggestion was favorably received.

On nomination, duly seconded, James K. Finch was elected to fill the vacancy on the board caused by the resignation of Professor Burr.

SUGGESTIONS FROM ALUMNI.

The ballot that was distributed last June, you will remember, called for a vote on these two alternatives: To discontinue publication of the QUARTERLY; or to raise annual dues to $4.50 and continue the QUARTERLY. Many alumni took this opportunity to write to the Secretary, explaining their votes and often adding criticisms and suggestions. In making selection from among these letters, for publication here, preference has been shown for those which contained profitable and helpful suggestions, even though they may have accompanied votes against continuing the QUARTERLY, on the conditions named. The suggestions have already been taken to heart by the editors, whose purpose in publishing them here is to awaken a corresponding amount of self-searching among the alumni themselves.

"The matter usually published in the QUARTERLY is such that, in my opinion, it may not appear to be worth the $3.00 yearly dues to a large proportion of the members. I make this statement with full appreciation of the difficulties of carrying on a publication of this character, and at the same time, supplying articles which are of greater general interest than those usually published. Nevertheless, it must be frankly admitted that the only tangible benefit derived by a very large proportion of the membership for their dues is the QUARTERLY. Now if that fails to satisfy them, it is naturally to be expected that there will be very much opposition to an increase in dues.

I believe that the Alumni Association should continue the QUARTERLY in some form that will be less expensive than the present one. For instance, it may be published in the shape of a bulletin, giving reports of the deliberations of the Board of Managers or other executive bodies connected with the Alumni Association. At the present time, such reports are not published in the QUARTERLY and so far as the greater part of the membership is concerned, we have no knowledge whatever of the activities of the Board of Managers and our officers.

Furthermore, an attempt might be made to use the QUARTERLY as a medium for the exchange of ideas between the members of the Association, and as a means of keeping members, in general, informed about the doings of their fellow members. In many ways the purpose of the QUARTERLY might be the same as that of the *Alumni News* except that it would enlarge the activities of the Alumni of the Schools of Science as distinguished from the Alumni of the University."

"It would seem to me to be a grave mistake to discontinue the publication of the QUARTERLY. It has been my experience, and doubtless that of many other occasional contributors to the QUARTERLY, that the publication reaches out to and is read by a widely distributed and highly specialized class of professional men. I personally think that the sphere of influence of the QUARTERLY could be extended by a somewhat greater emphasis of the research work being done by our graduates.

It is possible that our QUARTERLY, by reaching out further to graduate research articles, could do for Columbia from a more legitimate basis what the *American Journal of Science* is doing for Yale.

In this connection it would seem to me that a portion of the QUARTERLY could be used to advantage for a more thorough and up to date review of

current articles and papers, using one of the four yearly issues for each of the divisions, Chemistry, Physics, Geology and Engineering."

"The QUARTERLY is all there is in a membership of the Alumni Association; when the QUARTERLY suspends, I shall also."

"I think it would be a pity to abandon the publication of a magazine which is so great a credit to the Association and which, I have no doubt, serves a useful purpose not only in the Association, but in the Schools of Science and in the University."

"Even if this ballot should turn out unfavorably to the continuance of the QUARTERLY, I think an opportunity ought to be given to those who are sufficiently interested in, and loyal to, our old QUARTERLY to wish it continued, to make a special contribution to a fund which will enable you to meet the expenses for a period of three or five years to come. At a meeting, now little more than a year ago, one of the older graduates volunteered a subscription toward this end, and I am sure that a movement of this kind will find ample support."

"At the present time too few of the School of Mines graduates are members of the Alumni and this membership should be increased and not decreased. If the dues are increased to $4.50 it will mean a loss of membership, as the QUARTERLY does not at the present time interest all of the graduates of the Schools of Applied Science.

I cannot vote for the discontinuance of the QUARTERLY as I am certain that it will mean a loss of at least 50 or possibly 75 percent. of the present members.

Try and have the active members insert their professional cards in the QUARTERLY, this card to occupy only one-half inch space and to cost about $2.00 per year. This card is not intended as an advertisement but merely as an address list. I think you would find that 50 percent. of the Alumni would place their cards in the QUARTERLY.

The circulation might be further increased by issuing complete Alumni Notes. We are all interested to know where our friends are and what they are doing, and if every class is represented in the Alumni Notes I have no doubt that the subscription will be increased. Perforated blank forms for Alumni Notes can be embodied in each issue with printed request that they be filled out and returned to the QUARTERLY."

"The QUARTERLY has never struck me as a particularly useful publication and yet I would not like to go so far as to say it should be suspended. Every once in a while I find an article in it that is very interesting and its standard is certainly high. Were I to criticise it, I should say it was not of sufficient practical use.

What use is made of the $1.00 per annum per member contributed by the Association to the Alumni Council and just what function does this Council perform?"

"Since very few members of the Alumni Association 'participate,' is not $1.00 to Alumni Council from all the members too much?

Cannot a committee of 'business doctors' be appointed from the Alumni Association to look into the health of the QUARTERLY and arrange some expert advice, together with the Editors, for the Association to act on?"

"There is some spirited correspondence just at present in the *Engineering News* growing out of a bulletin issued by the University of Illinois, and it seems to me that there is no reason why the SCHOOL OF MINES QUARTERLY should not be an equally live wire if a little more genuine interest could be aroused among the Alumni. By genuine interest, I mean personal, selfish interest, not so-called 'college spirit.'

It would seem to me that many puzzling questions that arise in the engineering business requiring some experimental work for proper solution, which men in active practice, as a rule, have no time to make, could be very profitably turned over as theses subjects for the graduating engineers to pick from. Such questions could be listed in the QUARTERLY, and any

original work done by graduating students toward the solution of the problems would constitute first-class reading matter and be a real contribution to the profession."

"Though it does not often happen that the papers published in the QUARTERLY come within the scope of my own professional reading, I infer from the historical sketch which you have given that the publication of the QUARTERLY favors the interests of the Columbia Schools of Applied Science both at home and abroad, and that its discontinuance would be a misfortune."

"I believe that the QUARTERLY covers too broad a field to find a welcome place in the library of the average alumnus.

In lieu of the SCHOOL OF MINES QUARTERLY, as it now exists, let us have a periodical for each of the schools comprising the Schools of Science, publishing them less frequently if need be. Let the alumnus pay annual dues sufficient to cover the subscription to at least one of the publications, which he may select, with the option of subscribing for any of the others at cost rates.

Such a change would of itself tend to increase the interest of the alumni in the periodicals, but should be supplemented by endeavor on the part of th editorial staffs to induce the alumni to contribute more generally than has been the case with the QUARTERLY."

"My belief is that the magazine is being continued purely from sentimental reasons, that it fills no actual need which is not better supplied by the regular technical press and that it is wrong to make the whole body of the organized alumni contribute towards something in which very few are really deriving any value. I believe that the increased dues would be responsible for a considerable falling off in membership."

"I vote very reluctantly for the discontinuance of the SCHOOL OF MINES QUARTERLY but I feel that I can justify my vote on the ground that the articles contained in that medium will readily find acceptance in some other high class journal."

"To me it has only a sentimental value, inasmuch as I am not engaged in technical work, and I do not feel justified in paying even $1.50 purely for sentiment."

"The publication has never particularly interested me because most of its articles dealt with subjects that in no way concerned me or my work.

While I have kept up my subscription to the QUARTERLY, I have done so more from a sentimental standpoint than otherwise, but if the subscription price is to be raised without materially improving the publication, from my point of view, I shall have to drop out. Frankly though, I should dislike very much to see the QUARTERLY abandoned as I believe a scientific school of the size and standing of Columbia's should and can maintain a regular publication of sufficient interest to its graduates and others."

"Continue the SCHOOL OF MINES QUARTERLY. Separate its subscription from the annual dues. Let those who wish it, use it, those who need it, take it. It goes to perhaps hundreds who don't want it now."

"Living expenses are increasing so rapidly that I was compelled to discontinue subscription to several annual publications and other subscriptions and dues, and if the annual dues are increased I would be compelled to withdraw from the Association. I believe there are many more of my fellow men in the same fix."

"Cannot this SCHOOL OF MINES QUARTERLY be run by regular subscription, independent of the Alumni Association? I dislike very much to see this important publication discontinued, and for myself would gladly pay $1.50 a year subscription fee, but I do not think it the right thing to add this fee to the alumni dues and make all alumni take it whether they want it or not in order that they may enjoy the privilege of belonging to the Alumni Association."

BOOK REVIEWS.

The Ventilation of Mines. By R. A. S. REDMAYNE. Cloth; 5x8 in.; xiii + 231 pp.; illus. Longmans, Green & Co., London. 1911. $2.10.

This is Vol. IV of a series of monographs on mining. The author is the Chief Inspector of Mines of Great Britain and was at one time professor of mining in the University of Birmingham. He has had experience also as mine manager.

This little book differs from most treatises on mine ventilation in that it attempts a complete discussion of the subject and is not confined to a description of mine gases on the one hand, nor the mathematical theory of the friction of air in mines, or the theory of ventilating apparatus on the other.

The first four chapters are devoted to a short history of the subject and to a discussion of mine gases and the vitiation of air. It is followed by short chapters on the frictional resistance and circulation of air underground, and on the instruments used for measurement of the pressure, temperature, moisture, velocity and resistance of air currents, a chapter on ventilating plant, a chapter on the coursing of air in coal and metal mines, and a final chapter on explosions and mine fires. Perhaps the least satisfactory chapter in the book is the one in which nearly all books on ventilation are deficient, and that is the distribution of air underground and the methods of securing proper circulation of this air under different underground conditions and for different methods of working. If this portion of the book could be expanded to three or four chapters the value of the treatise would be very much increased. As it is we can recommend the book as one of the best of the elementary treatises on the subject. H. S. M.

The Business of Mining. By ARTHUR J. HOSKIN. Cloth; 4x6 in.; 224 pp.; illus. Lippincott & Co., Philadelphia. 1912. Price $1.50.

This is a popular treatise on mining operations and mining conditions intended for the information of investors. In the Introduction the author deprecates the lack of confidence in mining investments due to unscrupulous and dishonest promoters, or to failures resulting from ignorance or over-confidence of those in charge of mining operations. The author's avowed object is to overcome this prejudice, and in this book he endeavors to create a more optimistic view of mining, stating that his purpose . . . "will be served if the author can feel assured that his readers will finish its perusal with the belief that mining may be followed as a business with just *as much assurance of success* as attaches to any one of the many lines of industrial activity." The italics are ours. His optimistic attitude is illustrated in the frontispiece which is a view of Bingham Cañon, showing the steam shovel work of the Utah Copper Co., to which the author appends the statement, "This Mountain is Copper Ore." The reviewer is not aware that this has ever been claimed by those closely identified with the property.

The author was at one time professor of mining in a Western school of mines and is an associate editor of a prominent mining journal, and the book reflects the academic character of the author's experience. He devotes considerable space to definitions of mining terms and a general resumé of mining operations and mining conditions.

An emphatic protest should be made against some of the author's definitions. A better knowledge of English, with perhaps an occasional reference to Raymond's Mining Glossary, would have prevented him from making serious blunders. For example, "sluicing" is not synonymous with hydraulicking. "Exploitation" refers in a broad sense to the whole subject of mining, or in a narrow sense to the period of working, and not to the period of exploration or development. The term "shaft" cannot be restricted to vertical shafts, nor can the word "vein" be restricted to fissure veins, or the word "lode" to an assemblage of fissure veins, or to a fissured zone. The attempt to give forced or restricted technical interpretations to words which by long usage have obtained other or wider meanings is both unwise and hopeless and tends to increase confusion rather than to make it less. If the author desires to advocate reforms of this sort he should submit them to body of readers competent to discuss their value or advisability. In a popular treatise definitions should be confined to the accepted and usual meanings as established by long usage.

The attempt to cover the whole subject of mining in a book of this size is a difficult one and the author has had only moderate success in this attempt. Most of the chapters are superficial and unsatisfactory.

The small investor will find but litle assistance from the book to guide him in the safe use of limited amounts of money in the mining business, and the larger capitalist will not have to read between the lines to realize that he can only invest money safely under the direction of qualified mining engineers.

The chapter on Mining Claims gives an all too brief summary of the mining regulations of the United States, Canada and Mexico. The author ignores entirely common-law titles to mining property which prevail in a number of mining States.

The chapter on Placer Mining by dredging and hydraulicking is perhaps one of the best in the book, but is too brief, and omits the ordinary sluicing methods which latter the author confuses with hydraulic mining.

About one third of the book, chapters XIV to XXIII, is devoted to mining as a business and as an investment. The brief chapters on mine equipment and management are suggestive. The chapter on mine valuation is inadequate and the author has here misssd an opportunity to be of real service to the small investor. H. S. M.

Problems in Physical Chemistry, with Practical Applications. By EDMUND B. R. PRIDEAUX, M.A., D.Sc. Cloth; 8vo.; ix + 311 pp. D. Von Nostrand Co., New York. 1912. Price $2 net.

The aim of this book, according to the preface, is "to provide a series of arithmetical examples which shall illustrate the more important de-

velopments of physical chemistry. . . . A previous knowledge of the fundamental chemical laws, as well as the meaning of elementary physical magnitudes and operations, has been assumed throughout." An idea of the scope of the work can be gathered from the following principal chapter headings: Units and standards of measurement; Thermochemistry; Systems of one component; Mixtures; Gas reactions; Reactions in solution; Electro-motive force; Kinetics of molecular and radio-active change.

It is doubtless owing to the fact that physical chemistry is still taught in so many places, and through so many textbooks, from the purely descriptive point of view, that such a book as this exists. Possibly it is only the reviewer's idea, but certainly to him it seems best, in place of the purely descriptive, more or less academic point of view, to present the subject as a real and living one by illustrating it by aid of carefully considered problems; in short to make it the tool that it really is.

For one who has previously had only a descriptive course in physical chemistry, the working through this book would be much more laborious than the original course, but on the other hand it would be something worth doing, which possibly the other was not, or would seem not, by comparison.

As a text to accompany a descriptive course, or as one to provide further problems in a course already employing the problem method, the book is admirable, and shoud do much toward reforming the teaching of physical chemistry, for it provides the means for readily expanding and making useful any course which previously has been only descriptive. J. LIVINGSTON R. MORGAN.

The Metallography of Iron and Steel. By ALBERT SAUVEUR. Cloth; 7x11 in.; 402 pp.; illus. Sauveur and Bolyston, Cambridge, Mass. 1912. Price $6.00.

This book is offered to those seeking self instruction in the metallography of iron and steel; to teachers and students as a textbook; to users of iron and steel; and to the general reader interested in the scientific or practical features of the subject.

It is divided into 24 lessons which have been very carefully arranged and show much thought and study as to the correct way to present the subject to beginners. Still the book will be deeply interesting to those already proficient in metallography, because it contains new ideas, old ideas in new form, and a certain amount of matter, the theory of which is still open to debate. For anyone starting out to learn the practical metallography of iron and steel this book will be an enormous help. To those who have already obtained some skill in metallographic work it will serve as a guide for methods and for future studies.

The arrangement of subject matter is well taken. Starting with apparatus used by the author, it deals with pure metals, their structure and the effects of mechanical and heat treatment, wrought iron, low-carbon steel, medium-high and high-carbon steel, impurities in steel. The thermal critical points, their occurrence, causes and effects. Cast steel.

The mechanical treatment of steel, annealing hardening and tempering. Theories of hardening. Cementation and case hardening. Special steels, constitution, properties, treatment and uses. Cast iron. Malleable cast iron. Constitution of metallic alloys. Equilibrium diagram of iron-carbon alloys; and the phase rule. There are two appendices; one deals with manipulation and apparatus, embracing polishing and development of structure, mounting, and microscopes; the other treats of the nomenclature of the microscopic constituents, covering the report of Committee 53 of the International Association for Testing Materials of which Professor Sauveur was a most efficient secretary.

Criticisms of the book are few. The first is in reference to the pages; each section is a lesson with separately numbered pages, and hence it is difficult to refer to any particular topic. The section on "apparatus for the metallographic laboratory" and the first appendix on "manipulations and apparatus" ought to have been combined, and perhaps somewhat shortened by direct reference to trade catalogues. In regard to the illustrations, most of the micrographs are excellent, but one or two might be omitted or replaced by better ones, especially some which are not photomicrographs but drawings, and as such are wrong. Again some of the photomicrographs are reproductions of cuts and not of the original photographs and hence have lost much detail.

Numerous points might be criticised or discussed but these are merely matters of theory or faith; for example, Ewing and Rosenhain's theory of growth of grain; undisturbed cooling a condition necessary for the ready growth of crystals; effect of finishing temperature; and the doctrine that in slow cooling austenite passes through the stages of martensite, troostite, sorbite into pearlite.

Special mention must be made of the sections on the theories of hardening, on tempering, on case hardening and on alloy steels, particularly that dealing with the heat treatment, all of which are exceptionally well written and wonderfully clear.

The book is a good one, will supply a decided want, and will be undoubtedly welcome by all those who are interested in iron and steel, either from the practical or the theoretical standpoint. W. C.

Introduction to the Study of Minerals. By AUSTIN F. ROGERS. Flexible leather; 4x6 in.; 522 pp.; illus. McGraw-Hill Book Co., New York. 1912. Price $3.50.

Prof. Rogers, for several years successively Fellow and Instructor in Mineralogy at Columbia University, and later Associate Professor at the Leland Stanford University, has issued a very admirable textbook in which there are some decidedly original features. The author's purpose has been, as stated, to cover the whole field of mineralogy, as far as practicable, and give proper emphasis to all scientific, economic and other features. It may be said that in this attempt he has given more weight to the features which are usually reserved for advanced courses than is done in most textbooks and somewhat less weight to methods of determination.

A very praiseworthy feature is the recognition of the undoubted fact that the time has come to give the polarizing microscope a more prominent place in elementary work so that it shall "supplement the blowpipe in the determination of minerals." It is no longer a very costly instrument and its use should not be limited to advanced students or to the study of rock sections. Prof. Rogers introduces it for the study of crushed fragments according to the tables worked out by himself while an instructor at Columbia and he also uses it for studying the recrystallization of soluble minerals and for a few microchemical tests, all of which are highly characteristic. In the crystallographic portion, both the geometrical and the optical, there are many original drawings well adapted to their purpose and the explanations which accompany them are clear. In the mineral descriptions the author introduces what he calls "paragenetic" varieties, that is, under the heading "Occurrence" the different modes of occurrence which are more definitely separated than in the usual textbook. The book is well printed, with clear type, and is perhaps the most interesting textbook on the subject which has recently appeared. ALFRED J. MOSES.

Notes on Qualitative Analysis. By HORACE G. BYERS and HENRY G. KNIGHT. 8 vo.; xii + 181 pp. D. Van Nostrand Co., New York, 1912. Price $1.50.

Amongst the numerous smaller works on qualitative analysis, the present stands out as embodying a consistent attempt to present the subject from the modern standpoint. The theory, and a number of its applications in analysis, are first discussed. The next two parts deal with the reactions used in analysis. In the fourth part the plan for systematic analysis of a mixture is given. Throughout those last mentioned parts, frequent references to the theoretical explanations appear. A final part presents an outline of analysis for the rarer elements. In the systematic analysis the valuable dry-way reactions, often omitted, are satisfactorily presented.

One or two unfortunate errors occur, which will doubtless be corrected in a later edition. For example, the complex cyanides of copper (pp. 38 and 68) and of nickel (p. 40 and 45) are formulated as if they were cupric and nickelic derivatives, respectively, and the formula of the double potassium-nickel nitrite is entirely misstated.

An interesting feature of the introduction is the attempt to take into consideration the views of one opponent of the theory of ionization. But, as there is no room to treat the matter critically, the lack of quantitative foundation for the opposition and of constructive, theoretical or experimental work in support of it, is not made clear. Such incomplete statements are misleading to the uninitiated.

The book is well thought out, well arranged, and well printed, and should prove useful for classes which have to cover the subject in a limited time. A. S.

Practical Field Geology. By J. H. FARRELL and A. J. MOSES. Flexible leather; 5x7½ in.; 273 pp.; illus. McGraw-Hill Book Co., New York. 1912. Price $2.50.

The authors of this book combine wide experience in practical matters with intimate acquaintance with the doctrines of the scientists; hence the book is neither a catalogue of disconnected facts nor a judicial treatise on the merits of opposing theories. Practical hints and theoretical deductions often elbow one another in the same paragraph.

The first five chapters describe, without excess of detail, the field methods for surveying both topography and geology. For this work the author strongly recommends the plane-table, with stadia measurements. Chap. VI, on general suggestions, outlines the scope of an investigation. Chap. VII, on interpretation of geological data, sets forth the problem that has to be solved by every engineer engaged to pass on the value of a mining property, and the next chapter illustrates methods of solving fault problems graphically.

Chap. IX is a verbatim reprint of the paper by J. W. Roe on the application of descriptive geometry to mining problems. Chaps. X and XI review the leading theories of ore deposition and secondary enrichment. These chapters form a most valuable exposition of this puzzling subject. Chap. XII classifies the rocks and gives a concise table by which to assign the proper name to any ordinary rock, relying only on its visible characteristics. Chap. XIII contains valuable hints on the equipment necessary for a geological survey, and includes a paper by S. K. Bradford describing methods by which an engineer in a desolate locality can make assays with materials which can be carried in a suit-case. Chap. XIV discusses the features of outcrops, and XV the methods of recording drill-hole data.

Of the guide to the recognition of common or important minerals, by A. J. Moses, it is sufficient to say that it is of the same high order of excellence as the same author's more extended treatise on mineralogy. By means of the scheme of classification it is possible to identify any ordinary rock-forming or ore-forming mineral by nothing else than its hardness, its color, and the color of its streak. As a further aid in doubtful cases, a set of 50 simple blowpipe tests is tabulated, the appropriate ones for each mineral being indicated. These require no elaborate paraphernalia. E. K. J.

Essentials of Physics for College Students. By DANIEL W. HERING. Cloth, 5x8 in.; 350 pp.; 166 illus. D. Van Nostrand Co., New York. 1912. Price $1.75.

The scope of this book is more fully indicated by the sub-title "A Textbook for Undergraduates and a Lecture Course and Reference Work for Teachers and Other Students of Physics." The book has been developed from the author's lectures to college students. For the benefit of such students especially he has sought to keep the golden mean — at least for students who do not expect to make a business of physics in engineering or otherwise — between the fullness, and ofttimes dryness

of detail of theoretical physics, and the superficiality of physics regarded simply in its more obvious applications.

Features of the book are frank discussions of concepts and principles that are often treated too dogmatically and the introduction at fitting points of many quotations, with references, from masters or able expositors of the science. As suggestions to the teacher there is at the end of each chapter a list of suitable lecture experiments, requiring in the main only simple and inexpensive apparatus.

The book is open to criticism in detail; for example, the second law of motion is stated in terms that are meaningless or worse, except for historical purposes. But it will take its place with three or four other recent textbooks that are designed for use in the usual college course of a year's length. G. B. P.

Text Book of Physics. Third edition, revised. Edited by A. WILMER DUFF. Cloth; 5x8 in.; 686 pp.; 595 illus. P. Blackiston's Son & Co., Philadelphia. 1912. Price $2.75.

The salient feature of this book is its practicality. The treatment is mathematical, assuming knowledge of the rudiments of trigonometry, but we are not permitted even for the space of a page to lose sight of the points at which physical laws come into contact with our ordinary life. Applications of the science to the engineering arts are also emphasized, in fact are developed to a considerable extent, as in the section on thermodynamics. Sections on the ionic theory and radio-activity prove the book to be up to date. The illustrations are mainly diagrams, simple and to the point, just such as a lecturer would sketch on a blackboard.

The several sections are written by different authors, each of whom is professor of physics in his own institution, in the following order: Mechanics and Properties of Matter, by A. W. Duff; Wave Motion and Light, by E. P. Lewis; Heat, by C. E. Mendenhall; Electricity and Magnetism, by A. P. Carman; Radio-activity, by R. K. McClung; Sound, by William Hallock.

The index is extensive, and a special index to the various tables of physical and mechanical constants is provided. As a work of reference, an engineer should find this book valuable, as a means of reviewing his fundamental knowledge of branches a little out of his line. For college students, no better book on the subject has come to our notice.

E. K. J.

ALUMNI NOTES

Among several criticisms of the QUARTERLY which it has been our privilege to read in the correspondence brought out by the recent ballot, none has been expressed more frequently or with greater emphasis than this: That the SCHOOL OF MINES QUARTERLY does not keep in touch with the alumni, nor assist the alumni to keep in touch with one another. We believe that this reproach can be wiped out, but only with the coöperation of the alumni themselves. Of course, the editor can not invent news about the alumni. Arrangements have been made to secure full and accurate reports of all that goes on among the officers and students of the schools of applied science, but for outside events the editor is entirely dependent upon the assistance of the alumni.

As a suggestion, a blank page is loosely inserted in this issue, on which you are earnestly requested to write out any personal notes in which you have even the slightest reason to suppose that any other alumnus may be interested. This is not self-advertising, but just plain news. Items should be addressed to the Editor of the SCHOOL OF MINES QUARTERLY, Columbia University, New York City, who will hold himself responsible for their publication in due time.

Walter H. Weed, E.M., 1883, spent part of the Summer in examining the Kamloops property of the British Columbia Copper Co.; from there he went to inspect the Calumet-Sonora mine, of which he is consulting engineer, at Cananea, Mexico.

George S. Rice, E.M., 1887, is the author of a prelimnary study on "Mine Fires," published as Technical Paper 24 by the U. S. Bureau of Mines.

Charles Of, E.M., 1896, was the editor of Vol. XX of "The Mineral Industry" covering the year 1911, recently published by the McGraw-Hill Book Co., New York.

Robert G. Brown, E.M., 1889, of London, spent the early summer in Russia.

Edward L. Dufourcq, E.M., 1892, spent the month of July on a business trip to England and France.

B. B. Gottsberger, C.E., 1895, general manager of the Miami Copper Co., was elected President of the Miami Engineering Society, recently organized among the staff of the company.

Edwin C. Holden, E.M., 1896, has made recent investigations of mines at Nelson, B. C., and at Jarbidge, Nev. He spent the latter part of the Summer on the Atlantic Coast before returning to the University of Wisconsin, at Madison.

James F. Kemp, E.M., 1884, has been elected a member of the American Philosophical Society.

H. W. Nieman, E.M., 1911, has been put in charge of a mine a long distance to the northwest of Dawson, Yukon Territory.

J. M. Hoffman, E.M., 1911, was in New York in July. He is wth the Cy. Metalurgica Mexicana, San Luis Potosi, Mexico.

E. H. Dickenson, E.M., 1911, was in New York early in September. He is with the Beatson Copper Co., at Latouche Island, Alaska. H. J. Volker, of the same class, is with him.

Prof. Marston Bogert, of the department of chemistry, has been nominated by the Council of the Society of Chemical Industry for the presidency of that Society for the year 1912-13. For many years, and until surpassed by the American Chemical Society, this was the largest organization of chemists in the world. Its presidency has been held by such distinguished Englishmen as H. E. Roscoe, Frederick Abel, W. H. Perkins, James Dewar, Lowthian Bell, John Evans, Edward Thorpe, Joseph Swan, William Ramsay, and Boverton Redwood. But three Americans have been honored by election to its presidency, Prof. Chas. F. Chandler, William H. Nichols, and Ira Remsen.

Robert Marsh, Jr., E.M., 1907, of the Braden Copper Co., in Chile, visited London in September.

Thomas H. Leggett, E.M., 1879, has been appointed consulting engineer to the mining department of the American Smelting and Refining Co., at 165 Broadway, New York City.

Heinrich Ries, Ph. D., 1892, was engaged during the Summer in examining the clay deposits of British Columbia, for the Canadian Department of Mines.

Alexander P. Rogers, C.E., 1898, was at Panama in September, on professional business.

Cecil W. Pocock, E.M., 1906, for the past three years with the Cerro de Pasco Mining Co., is now in charge of the Santa Clara mines, at Morococha, Peru.

W. H. Aldridge, E.M., 1887, who takes charge of W. B. Thompson's mining interests, has left Los Angeles and now has his office at 14 Wall St., New York City.

Benjamin Magnus, E.E., 1900, for five years general manager of the Electrolytic Refining Co., at Port Kembla, has been appointed to the corresponding position with the Mount Morgan Gold Mining Co., at Mt. Morgan, Queensland. He will continue as adviser to the Refining Company.

R. B. Watson, E.M., 1891, general manager of the Nipissing mines, Cobalt, spent a month of the past Summer at Carlsbad, Germany, in an effort to rid himself of rheumatic trouble. He returned on Sept. 27.

R. A. McGovern, E.M., 1910, is with the Guggenheim Exploration Company, at their property at Chuquicanata, near Antofagasta, Chile.

H. E. Crawford, E.M., 1899, owner and manager of mines in Mexico, visited New York early in the Summer.

C. T. Dantziger, E.M., 1905, after several years at different places

in Montana and Central America, has returned to the East; his present address is Spring Valley, N. Y.

John H. Morecroft, Assistant Professor in the Department of Electrical Engineering, was married on Oct. 15, 1912, to Aimeé Henry, at Rockville, Md.

T. W. Skinner, E.M., 1912, has gone to Chile to take a position on the engineering staff of the Braden Copper Co.

Philip Kraft, Jr., E.M., 1912, will spend the coming Winter in studying at the School of Mines at Berlin, Germany.

H. D. Hawkes, E.E., 1896, after 14 years with the General Electric Co., has left that company and joined the United Metal Selling Co. in a responsible position and is actively engaged in booming the use of copper.

H. G. Chatain, E.E., 1897, has recently sailed for Europe on business for the General Electric Co. It is generally understood that the General Electric Co., is about to undertake the manufacture of oil engines of the Diesel type and that Mr. Chatain will be in charge of the engineering side of this work.

H. S. Hertzog, E.E., 1911, is in charge of testing the new electric locomotive built by the General Electric Co., for the New York Central R. R., which is designed to haul a train from New York to Albany without change of locomotive.

Charles M. Warner, Met. E., 1912, is construction engineer at the Midvale plant of the U. S. Mining and Smelting Co., at Midvale, Utah.

R. Tarantous, E.M., 1912, is with the Shannon Copper Co., Metcalf, Ariz.

E. N. Kleinbaum, E.M., 1912, is with the Dominion Reduction Co., at Cobalt, Ont.

R. M. Jones, E.M., 1905, is with the West End Consolidated Mining Co., at Tonopah, Nev.

Frederick L. Rupp, E.M., 1908, is president of the Rochelle Construction Co., contracting engineers, New Rochelle, N. Y.

Charles D. Shrady, C.E., 1895, recently returned from a trip around the world. He has an office at Allentown, Pa., for the practice of landscape engineering.

Julius R. Wemlinger, C.E., 1900, President of the Wemlinger Sheet Piling Co., 11 Broadway, New York, was a delegate to the Twentieth International Irrigation Congress, held in Salt Lake City, Oct. 1, 1912.

Eugene Pitou, Jr., C.E., 1906, was recently married to Gertrude M. Murray, at Richmond Hill, L. I. He is secretary of the Municipal Art Society, and is associated in business with the New York Scaffolding Co., 55 Liberty St., New York.

William H. Boynton, Chem., 1906, has resigned his position with Joseph Fahys & Co., Sag Harbor, N. Y., to take a similar position with the New Jersey Zinc Co., at Palmerton, Pa.

H. L. Mead, E.M., 1905, was a recent visitor to the School of Mines. He has been engaged in the inspection of mining properties in various parts of South America, and expects to start soon on a similar piece of work in Guanajuato, Mex. Permanent address, 211 West 107th St., New York.

J. B. Stewart, E.M., 1901, is manager of a new iron mine being developed at Millersville, Lancaster county, Pa.

M. A. Lamme, A.M., 1904, formerly Instructor in Mineralogy at Columbia, is now an official in the Ministerio de Industrias, at Montevideo, capital city of Uruguay.

F. S. Foote, Jr., E.M., 1904, is professor in the department of Civil Engineering at the University of California, Berkeley, Cal.

F. A. Ayer, E.M., 1910, has been promoted from the position of chief sampler to that of foreman at the Santa Rosa and Summit properties of the Detroit Copper Co., Morenci, Ariz.

George H. Clark, C.E., 1893, with the Holbrook, Cabot & Rollins Corporation, Engineers and Contractors, 6 Beacon St., Boston, Mass., has recently been engaged in the placing of pneumatic caisson foundations for a 20-story building in St. Louis, Mo.

Robert W. Briggs, C.E., 1911, is head of the department of Engineering at Trinity College, Durham, N. C.

Gilbert Vulté, C.E., 1909, is engaged, under the U. S. War Department, in construction work at West Point, N. Y.

Albert P. Hallock, Ph.D., 1880, is Treasurer of the American Chemical Society, with office at 3 James St., Yonkers, N. Y.

E. B. Latham, E.M., 1909, is geologist with the Kern County Oil Protective Association, with office at Taft, Cal., P. O. Box 53.

J. H. MacGregor, Assistant Professor in the Department of Civil Engineering, in charge of the testing laboratory, is spending a year's leave of absence at Messilla Park, N. M., where he was called by the death of his father, a prominent ranch owner in that district.

C. Pigott, E.M., 1910, is assistant superintendent of the A. S. & R. Co's. plant at East Helena, Mont. Just before going to press we learn that he is the proud father of a son.

John T. Roberts, Jr., E.M., 1907, is manager of the Wanakah Mining Co., developing the Bright Diamond group at Ouray, Colo.

Some of the 1911 mining engineers are located as follows, according to a bulletin issued by their secretary, T. M. Bains, of Britannia Beach, B. C., under date of July 1, 1912: C. E. Dwyer is with the Federal Mining and Smelting Co., at Mullan, Idaho. A. Mendelsohn is on the engineering staff of the Champion Copper Co., at Painesdale, Mich. P. R. Iseman is with the Yukon Gold Co., at Dawson, Yukon Terr. P. D. Wilson is at Cumpas, Sonora, Mex. W. F. Palmer is surveyor with the Leonard Copper Co., Gleeson, Ariz. J. M. Hoffman is surveyor with the Cia. Metalurgica Mexicana, at San Luis Potosi, S.L.P., Mex.

R. L. Strobel is chief chemist at the plant of the A. S. & R. Co., at East Helena, Mont. S. L. Wise is engineer with the Vermont Copper Co., So. Strafford, Vt. K.I. Guiterman has been travelling extensively in Europe; permanent address, care the A. S. & R. Co., 165 Broadway, New York. F. A. Ayer is with the Detroit Copper Mining Co., at Morenci, Ariz. E. Latimer recently returned from a vacation trip to England; permanent address, The Princeton Club, New York. C. B. Whitwell is in the operating and consulting business, with office at Nevada City, Cal. Clark G. Mitchell is still at Britannia Beach, B. C., and so is W. L. Thomas, in the employ of the Britannia Mining and Smelting Co. D. B. Scott is engineer in charge of underground operations of the Miami Copper Co., Miami, Ariz.

A group of the 1912 mining engineers have reported their movements to their secretary, Harry F. Cornwall, the Federal Lead Co., Flat River, Mo., who publishes them under date of Oct. 1, 1912, as follows: B. C. Staiger is at the Live Oak mine of the Inspiration Consolidated Copper Co., Miami, Ariz. R. A. Semple is with the Miami Copper Co., at Miami, Ariz. G. A. Shaw is on the engineering force of the Baltic mine at Painesdale, Mich. J. E. Bell is with the Chile Exploration Co., operating at Chuquicamata (via Antofagasta), Chile. Jay P. Wood is assayer with the Wanakah Mining Co., at Ouray, Colo. P. Kraft, Jr., spent a busy summer in European travel, visiting most of the important mines and metallurgical works in Germany. He will remain for another year to study in Berlin. N. R. Sethna left New York in November, 1912, to return to his home in India.

A. R. Fletcher, E.M., 1911, is superintendent of the Parral unit of the American Smelters Securities Co., at Villa Escobedo, Chih., Mexico.

Thatcher T. P. Luquer, C.E., 1889, consulting engineer, announces the removal of his office to 15 East 40th St., New York City.

Commencement exercises in June, 1912, included one novel and pleasing feature. It is reported by Professor Kemp in the following words: "The nicest thing about commencement was this. Ben Lawrence, our Alumni Trustee, was moved to get the Dean to assemble all the School of Mines graduates at 12:35 under the big bust of Professor Egleston in the hallway of the School of Mines, together with their parents, sweethearts and such alumni as came along. Dean Goetze said a few words. Professor Munroe called them up in alphabetical order and Ben Lawrence pinned the crossed hammers on each man's coat, as a personal gift from him, and then called on me to add a few words. Mudd, of the graduating class, made a graceful acknowledgment and we shook hands all around. It was an awfully nice thing of Lawrence to do, and I hope he will keep it up another year."

Edward Eggleston Seelye, E.M., 1911, of Lake George, N. Y., took his own life on Nov. 9, 1912, at St. George, Staten Island. He had been suffering from a nervous disorder, and had been under the care of a physician for some time. He received the degree of Civil Engineer from Cornell, and was among the most promising mining engineers

graduated at the School of Mines within recent years. He was employed by the Orford Copper Co., at Bayonne, N. J.

Lynne F. Hazzard, E.M., 1912, on his way home to Bisbee, Ariz., soon after graduation, stopped to pay a visit at Oklahoma City on June 16, and while swimming was taken with a cramp and drowned.

During the past two months a number of inquiries have come to members of the staff of the School of Mines and of the Schools of Engineering for the names of graduates open for positions. It is often difficult to suggest suitable candidates for such positions because graduates often neglect to keep us informed of their whereabouts.

Nov. 15, 1912. ROBERT PEELE.

WANTED—Brief, timely articles on subjects connected with recent progress in the engineering arts—Civil, Mechanical, Mining and Metallurgical Engineering — also in Chemistry and Economic Geology, for publication in the SCHOOL OF MINES QUARTERLY. Polished literary style not essential.

An author will receive 50 reprints of his article free, and as many more as he wishes at the bare cost of printing.

Address manuscript to the Editor, SCHOOL OF MINES QUARTERLY, Columbia University, New York.

ESTABLISHED 1851

EIMER & AMEND

205-211 Third Ave., New York City

HEADQUARTERS FOR

Chemical Apparatus, Chemicals and Assay Supplies

Mine Laboratory Supplies
Balances and Weights of every Description
Pyrometers, Optical, Thermo-Electric, Etc.
Electric Furnaces for Laboratory Purposes
Platinum Ware—best hammered.
Chemicals, Chemically pure and Technical, Etc.

COMPLETE LABORATORY AND PROSPECTING EQUIPMENTS

First Quality Supplies Only
Prompt Service

POWER TRANSFORMERS

There is no other type of transformer on the market to-day in which strength, high efficiency and good regulation of voltage are combined so successfully as in the Crocker-Wheeler core type, butt joint transformer. Time and again comparisons have been made between it and transformers of other makes, and the Crocker-Wheeler apparatus proved superior in every case. Large numbers of these transformers, now installed in all parts of the country, are proving this daily by their faultless operation.

Write for our bulletin 154.

LIGHTING TRANSFORMERS

Everything you want in a lighting transformer is found in our REMEK type. They have durable and strong insulation, low core loss, high all day efficiency, good regulation for lighting, good regulation for motor loads even with low power factor, low and uniform heating, low exciting current, durability and ample capacity for overloads, simplest mechanical construction, facility of repair, and light weight.

Write for our bulletin 151.

CROCKER-WHEELER CO.

Ampere, N. J., Baltimore, Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, Indianapolis, Los Angeles, Milwaukee, Newark, New Haven, New York, Philadelphia, Pittsburg, Salt Lake City, San Francisco, Springfield, Syracuse, Washington, D. C.

Min & Met
Per 27

VOL. XXXIV. NO. 2. JANUARY, 1913

THE

SCHOOL OF MINES QUARTERLY.

A JOURNAL OF APPLIED SCIENCE.

CONTENTS

PRINCIPLES OF MINE VALUATION. By *James R. Finlay*..... 87
POWER-PLANT ECONOMICS — II. By *Horace W. Flashman*.. 96
MANUFACTURE OF RAW SUGAR IN THE PHILIPPINE AND HAWAIIAN ISLANDS. By *C. A. Browne* 119
A SYSTEM OF MINE ACCOUNTS. By *Mason T. Adams*..... 137
NOTES ON BORE-HOLE SURVEYING. By *Sidney L. Wise*..... 149
ELECTRICITY IN ANTHRACITE MINING. By *W. P. Jennings*.. 151
DEPARTMENTAL REPORTS FOR 1911-12..... 155
BOOK REVIEWS 171
UNIVERSITY NOTES 174
FACULTY NOTES 180
ALUMNI NOTES 182

COLUMBIA UNIVERSITY
NEW YORK CITY

Registered at the New York Post Office as Second Class Matter

TWO DOLLARS PER YEAR. FIFTY CENTS PER NUMBER.
All Remittances should be made payable to order of "The School of Mines Quarterly"

Same Boat?

Letter and Editorial comment thereon appearing in The Mining & Scientific Press, December 21st, 1912.

Filter Patent Litigation

The Editor:

Sir—My interests being affected by the recent decision sustaining the Moore process patent, I called the attention of my patent counsel to the editorial appearing in your issue of November 23, having got the impression from reading the editorial that a judgment of the Circuit Court of Appeals for one district did not affect one who might be an infringer in any one of the other eight districts. The advice that I have received is to the effect that any such impression is entirely erroneous and that while one taking the pains properly to analyze and weigh your editorial, paragraph for paragraph, is likely to reach the conclusion that you intended no such construction put upon it, yet a mere cursory reading is likely to convey such impression to others as it did to me.

I am given to understand that a decision by one Circuit Court of Appeals is in about ninety-nine cases out of a hundred recognized by every Circuit Court of Appeals as prima facia for the granting of at least a preliminary injunction, and that the instances are very rare when the judgment is not considered final, or in effect the same as if it were the judgment of the United States Supreme Court. The present Circuit Court of Appeals, I am advised, was established simply to relieve the United States Supreme Court of consideration of patent and other causes.

I have at all times been willing to concede that George Moore solved the slime problem but one of those who it now turns out was evidently arguing for "revenue" only, succeeded in convincing me that the Moore process patent would never be sustained by the Courts, and I must confess that with the great number of contrivances previously patented and which were claimed to be "perfect anticipations" of Moore's patents, that I concluded to take my chances with the somewhat extensive list of persons who had evidently become similarly convinced.

It now appears that Moore protected his position fundamentally by obtaining a "process patent" and that the steps of his process are not anticipated by any one of the apparatus patents which I had presented to me as "perfect anticipations" of Moore's process patent. I think that I have now discovered just about where I am at, and possibly the publication of this letter might serve a useful purpose to others who have been sailing in the same boat with me. R. R. Reutlinger.

Philadelphia, November 30.

[We regret that our editorial should have been misunderstood even by one reading it hastily. In pointing out the possibility of further litigation we had no intention of suggesting that there was more than a chance that the decision just rendered would be reversed. Indeed the latter seems entirely improbable, and we have therefore urged that from now on negotiation rather than litigation is in order. We are glad to see that our correspondent's attorney agrees with us in analysis of the case.—Editor.]

Is It a Case of "Same Boat" With You?

If so we will stand ready to enter into negotiations for a settlement on the lines previously announced.

THE MOORE FILTER COMPANY

NEW YORK, U. S. A.

THE
SCHOOL OF MINES
QUARTERLY

VOL. XXXIV. JANUARY, 1913. No. 2.

PRINCIPLES OF MINE VALUATION.*

BY JAMES R. FINLAY.†

Almost all enterprise is based on valuation of some kind. Practically all transactions in mining property, whether it be in stocks, bonds, or actual ownership, are based on some kind of an appraisal of values. If you expect to be employers instead of employes you should begin at once to study the factors which give value to things. You can not buy intelligently nor sell intelligently until you know how to form an estimate of what a given property is worth to you, to the man you are dealing with, and to anyone else who might be brought in. It is only by such knowledge that one can discern a bargain or avoid a disastrous venture.

This generalization has no more application to mining than to any other form of business; but it certainly does not apply to mining less than to other forms of business. I think that no more unfortunate idea is taught to young mining engineers than that they are to consider themselves merely as professional men, like doctors or ministers. I would not speak of this if such an idea had not been cultivated in certain quarters. It is true that some mining engineers are employed to do technical work as referees between conflicting interests. Professional honesty is of course an absolute essential, but the honesty of a mining engineer is the honesty of business and of common sense. It is not in the least desirable for a mining engineer to avoid business transactions; on the contrary he should go into them as soon as possible and study the subject in every possible way. I do not see how any man can make a success of mining who does not realize that it is a strictly commercial busi-

* A lecture in the Department of Mining, Columbia University, Dec. 2, 1912.
† Consulting Mining Engineer, 52 William Street, New York.

ness; that the only result to be sought is commercial success; that the only scientific and technical attainments that are worth anything are those which contribute to commercial success. Attainments of a different character are, of course, worth while; but they are valuable to a mining engineer because he is a man and a citizen, not because he is a mining engineer. They would be equally valuable in every kind of profession. Success in business is measured in money. Technical skill is efficient only if it pays. One can judge of the value of technical excellence only if he is prepared with a knowledge of what constitutes the money value of the results of such technical excellence.

Undoubtedly this view of the mining business, or profession, has been gaining ground in our universities and technical schools. Formerly, I think, education was considered to be merely a training in principles. Technical training was a discipline in the science of action (I coin the expression), an exposition of the principles of doing things. Whether it was worth while, in dollars and cents, to do a thing was to be found out later in actual business. Now I think it is recognized that, while making money is of course a matter of actual occupation in business, there are certain general principles underlying the value of things, which are well worth study. This is the study of political economy, which is largely taught in all our universities. The mining engineer sooner or later comes into contact with this subject and is bound to find it interesting and important. I shall try now to advance a few ideas about the valuation of mines, which I think are basic enough to come under the head of general principles.

The first thing to which I wish to draw your attention is the general subject of valuation. What is it that causes a price to be fixed for commodities or properties? In general, there are two methods of fixing values; one is the empirical method, and the other, the constructive. The empirical method of fixing values is simply to obtain a record of facts — of transactions. A man will assume that a town lot is worth $100 because he finds that people have bought and sold similar lots for $100 apiece. Nearly all commodities of a retail nature are valued in that way, and it is perfectly logical that they should be, because each actual transfer is a bargain between the buyer and the seller, theoretically at least. The man

who sells for a certain price does so because he believes he can do it profitably. On the other hand, the man who buys figures the same way from his side. Consequently we find that wheat, iron and copper, as commodities, are valued empirically by merely ascertaining what sales are made; and fluctuations of price are established by supply and demand. If a commodity is anxiously sought for by more people than can be supplied, they bid up the price.

The constructive method is that which places the value of commodities in a more or less scientific manner — builds up logically an estimate of what it properly should be worth. This naturally applies to properties which are dealt in only occasionally, for which there is no precedent of an actual sale of the equivalent thing. You will easily see that mines belong to that class of property.

Hardly any two mines are exactly alike; therefore you cannot say logically that because one mine is worth one million dollars, another mine is also worth one million dollars — at least you cannot say so until you have gone through the factors which give both properties value, and have found that they are identical. It is to those factors which do give values to mines that I wish to call your attention now.

I have always supposed, and I think that nearly all mining engineers agree with me, that there are three or four fundamental factors about a mining property which determine its value. These are:

1. The average cost of securing the products of that mine.
2. The average price at which those products can be sold.
3. The rate of production of the mine.
4. The time for which that output can be maintained.

I do not intend to go into detail as to any of these factors, but to point out some things which I think are worth considering, in the hope that later you will think about them and learn the details for yourselves.

In regard to the average cost: In the case of going concerns, that average cost can be obtained empirically by simple reference to the books — to what has actually been done on the property. That seems and sounds exceedingly simple. As a matter of fact it is not easy. I made the mistake once of thinking that it was. I bought

a mine in Joplin, Mo., to be specific, on a record of its cost for six months. The reason I did not go further back was that older records were not to be had, and also because during this particular six months the property had reached a substantial basis. I figured that the concentrates from that mine could be produced for about $20 per ton and I also estimated that the property should produce so much ore and that the price would be a certain figure. It happened that developments proved that I was right about the price and the quantity of ore on the property, but they also proved that I was wrong on the question of costs. It cost us nearly 75 percent. more to produce concentrates from that ore than the record of the property showed. There were times when we produced concentrates for $15 a ton, but that was not representative of the whole period of working the mine. I think you will find to-day that a great many of the cost statements given out by different companies for fixing the value of their stocks are only temporary or occasional costs, and will not stand analysis, and cannot be maintained during the whole life of the property.

Then there is another factor in which people deceive themselves, unconsciously, but in the simplest and most obvious way imaginable. They keep on doing it, always have done it, and I suppose always will do it. That is, by failing to see the relation between expenditures that are for plant and those for keeping it going. In keeping books it is very easy to say that the construction of a building, the remodeling of a mine, or the building of a new mill, is something that will not happen again, that it belongs to the property and not to the operation; to a certain extent that is true, but it is a fact, which I have verified by looking up a great number of mines, that the so-called operating costs are ordinarily not more than 60 to 80 percent. of the total cost. Until a mine is shut down, there is always some expenditure to be undertaken which a bookkeeper may think will not be repeated, that it belongs to the plant, but these things keep occurring so constantly that one who is figuring on costs must count on them. That is, to form an estimate that is correct or approximately correct will require a good deal of judgment and experience.

Another thing I believe to be true is that any estimate of cost, or valuation, or anything relating to the future, is a good deal of

a guess. One who thinks he can estimate a cost, whether of a going concern or a concern to be started, to a fraction of a cent, or to any fixed amount, is simply mistaken. All you can do is to put a round figure which seems to be pretty near the facts. Of course, the difficulty of estimating costs at a mine which is not yet opened is considerably greater than at a mine that is going, for very obvious reasons.

The next fundamental factor in forming an idea of the value of a mine is the average price of its product. I will go so far as to say that this is the most important factor to be considered. The literature on this subject, I think, has not done justice to the importance of prices because apparently a good deal of the best thought given to the subject of valuations has been by English engineers who had in mind principally gold mines. Gold, of course, is the only product of mines the value of which is fixed; consequently most of the discussions on mine valuation among engineers have been devoted to the third factor, which I will come to later, viz., the uncertainties in amount of ore in a mine and the part that developed ore plays in the estimate of a total valuation.

As an example of the tremendous importance of the price of a product in mine valuation, I will cite from my report on the Michigan mines. At the time of that report, the price of copper was 12¼c. per pound. A group of copper mines in Michigan were producing, and had been producing 200,000,000 lb. of copper per year at a cost of 10c. per pound, in round figures. I valued the mines on the assumption that the average price of copper would be 14c. per pound as against the current price of 12¼c., and I put a valuation of about $70,000,000 on that basis. Roughly, at 14c. a pound, the earnings would be $8,000,000 a year, and the total value of the group would be nine times that, or $70,000,000. You will find it is a difficult thing in commercial transactions to figure steadfastly on a price that is different from the present price. When I talked about copper averaging 14c. a pound, many said, "That is not the present price, it is 12¼c." Some thought the price might go even lower instead of higher. I think if I had not been prepared by several years' study of that very subject, I would certainly have used a lower figure than 14c. a pound for the average price of copper. At any rate, the value I put on them was nine times their annual income at 14c.

If I had used the current price of 12¼c., their annual income would have been only $4,500,000. As a matter of fact, within less than 12 months after the report was made the price of copper had gone up to 17¾c., and the usual proportion of people thought that the price would go still higher, and that this might be the average. If it had been the average, the earnings of these mines would have been nearly $15,500,000 at that price of copper.

Now let us look at what these figures mean in terms of the life of a mine. If I had figured that the mines were worth $70,000,000 at a price of 12¼c. per pound, I would have had to believe that the mines, on the average, were good for 40 years' life, instead of about 13 years. If, on the other hand, I had assumed that the price would be 17¾c., in order to make the mines worth the price I put on them they would have to last only five or six years. Therefore the fluctuations of price in less than a year corresponded to an extension in the life of those mines from five or six years to 35 or 40 years. Here again I am dealing in a mere approximation. I suppose these mines produce about 20 lb. of copper per ton; therefore to get 200,000,000 lb. of copper per year, you would have to mine 10,000,000 tons. Therefore, the figures that I actually used meant that I believed there was 130,000,000 tons of copper ore which could be depended on. That is an enormous amount of ore. Figured roughly, that would mean a lode of solid ore five miles long, of the average width of 12 ft., and 5,000 ft. deep; it was actually obtained by projecting the production of the mines and the development of the mines far below their present position. Now if I had to estimate on 12¼-c. copper, I would have had to figure on 40 years' life, or I would have had to believe that there were 270,000,000 more tons there than I thought I was justified in believing. On the other hand, if we put the value at 17¾c., I should have had to figure on only 50,000,000 or 60,000,000 tons of ore. Therefore, I say, as affecting the value of mines, the actual fluctuations of price within one year were equal to an uncertainty in the ore production in those mines of more than 300,000,000 tons. An engineer is not likely to make a mistake like that with mines so fully developed as these Michigan properties, many of which are worked to a great depth, are well managed, and have their outlines very

well shown. He could, however, easily make just as important a mistake as that in figuring on his average price of copper.

As a matter of fact, I do not think the 14c. price I used was an accurate figure. I have believed that copper would average more than 15c. per pound, taking into view the development of the business, but 14c. was as far as I thought I could go. I do know that mines have been valued within the last five years on prices estimated all the way from 12c. to 20c. Just imagine what a difference that makes in the estimated value of those mines! I know a very important mine in Mexico, the organizers of which believed that copper would not average less than 20c. per pound. I know of mines, on the other hand, that are being valued on an expectation of 12½c. per pound. The same uncertainty applies to all kinds of metals.

I ran against the same difficulty with another group of mines during that same Michigan study. In the iron mines I assumed a price for iron which happened to be almost the same as the price for the year 1911, which was a dull year in the iron business. In this case, however, the price, instead of going up, as the price of copper did, went down about 50c. a ton the next year. Now the margin of profit for those iron mines, during the period that I figured on, was just about $1 a ton, so that if you take off 50c. a ton you cut the profits in two. Of course, during all this last year, I have been exposed to a good deal of criticism by the iron miners, because they say I assumed a wrong price. While it may have been wrong for the year 1912, I notice that prices for the year 1913 have been fixed lately and at a figure very close to my average, in fact, almost identical with it if certain reductions in freight rates be considered.

In both the iron and copper calculations, I have been asked a great many questions as to how I arrived at the prices I assumed. Here there are certain evidences which can be used as guides, and are well worth studying. One general fact about the prices of all mining products is that they vary in cycles or in waves, irregularly of course. If, after a period of high prices, you find that prices are definitely going down and reach a new level, it is pretty safe to believe that the lower level of prices will continue several years. On the other hand, after a period of low prices, when once the

metal rises markedly, it is pretty safe to assume that it will stay at a higher level for several years. Those fluctuations are things very well worth studying. It is a matter on which you cannot form opinions right away. You will find in a year from now that you will be justified in holding a different idea from the one you may have at present.

The valuation of a mine, while in the long run it depends on the average, is influenced a good deal by the present price. If you have a copper mine that is going to last ten years, and you expect 18-c. copper for three years out of those ten, it is a matter of considerable consequence to your property whether that 18-c. price comes during the first three years or during the last three years of the life of your mine. If it comes in the first three years you will get your profits and may invest them, perhaps in other directions, and the interest on that money for the following years will be worth a great deal to you. I must confess, in regard to the question of profits, that I was wrong when I wrote my book on the "Cost of Mining" in laying too much stress on average price. I now believe the public is right when it puts a higher value on properties during periods of high prices for metals. That is merely an assertion which I offer you to think about. It is a curious thing, which anyone can observe by watching stock quotations, that the prices of mining stocks vary almost parallel with the price of the metal itself. When copper metal goes down, copper stocks go down. I always used to think that this was illogical, but I have come to the conclusion now that the public, which bases its valuations on present commercial conditions, has been more logical, on the whole, than the mining engineer, who has laid so much stress upon the life of a mine and the uncertainties of its future.

The question of the life of a mine is not to be overlooked, by any means. In many cases that is the most vital factor, particularly in the case of gold mines, because there fluctuation of price does not enter. Take, for instance, the Goldfield Consolidated. There is a property which has been making a spectacular showing in dividends, but it has always been recognized that its life was uncertain; and now, in spite of the fact that for two years it has been paying very large dividends, the price of the stock has been so low that the dividends have equalled 50 percent. of its market value. Re-

cently the stock has been selling for $1.75 per share; the actual dividends paid during the past year have been $1.60 per share. Now, if the mine were valued in the way some copper mines are valued, paying dividends, say, at the rate of 6 percent. of the selling price, the price to be put on Goldfield stock would be $20 per share. In that mine the whole question centers on the length of its life. I speak of it beacuse this is so contrary to usual experience. I do not know of any other case in which the public has been warned, or has become convinced of a mine's exhaustion so long in advance.

On the other hand, there are some mines with an expectation of long life which cannot show any ore reserves at all. Certain mines at Tintic, Utah, which I should be willing to value on an assumed life of five or ten years, do not show ore reserves for even three months. The reason is that those bodies grew in a fashion which prevents the ore reserves from being developed. They occur in an immense mass of limestone, through which mineralizing solutions have gone, and have been diverted by various intersecting fissures. These orebodies are irregular, sometimes small and sometimes swelling up to large size; sometimes they go down vertically four or five hundred feet, forming a pipe, then abruptly go off horizontally for four or five hundred feet, and then up again, then shooting to the right or to the left. If nothing were known about the persistence of those orebodies, one would be justified in being exceedingly skeptical about the future; but the experience of 30 years has shown that those deposits, in spite of their irregularities, are exceedingly persistent. In making his valuation the intelligent engineer will of course consider this fact a pronounced asset.

POWER-PLANT ECONOMICS.— II.

BY HORACE W. FLASHMAN.*

3.— WATER-RATE EQUATION IN PRACTICAL PROBLEMS.

From the results brought out in Section 2, it appears that there are many engines of which the steam economy characteristics admit of mathematical expression, in the simple form: $y_1 = A \div x + B + Cx$, where y_1 is pounds water per kw.-hour; x is load in units of 1000 kw.; and A, B, C are constants appropriate to each case.

From the curves presented herewith, as typical, and from others which have been examined, I feel safe in saying that where the tests have been carefully conducted, a curve can be determined which will be practically coincident with the test curve over a range in excess of the usual operating range. The only exceptional point may occur on the maximum overload, where the test may show 2 or 3 percent. higher than the equation. In other cases, where the tests have not been conducted with so great care, the smooth, mathematical curve represents a close average through the test points.

Based on these equations, an analysis of several practical problems will be presented in this section, and application will be made to the engines under consideration.

PROBLEM 1.

To find the most economical load on an engine, given its water-rate curve.— Taking the equation of water-rate as stated above, at most economical load, the water-rate is a minimum, i.e.,

$$\frac{dy_1}{dx} = \frac{d}{dx}\left(\frac{A}{x} + B + Cx\right) = 0. \quad \text{That is, } C - \frac{A}{x^2} = 0.$$

Hence $x^2 = A \div C$, and $x = \sqrt{A \div C}$ at minimum water-rate.

In special cases, e.g., throttle governed engines, C is either zero, or very small; the water-rate curve will then not cease to fall with

* Westinghouse Electric Co., New York. A thesis, of which the full title was "The Economical Use of Power-Plant Units having Known Characteristic Curves," presented for the degree of Master of Arts in Columbia University, April, 1910.

increase of load, and the most economical load will be at the maximum overload attainable.

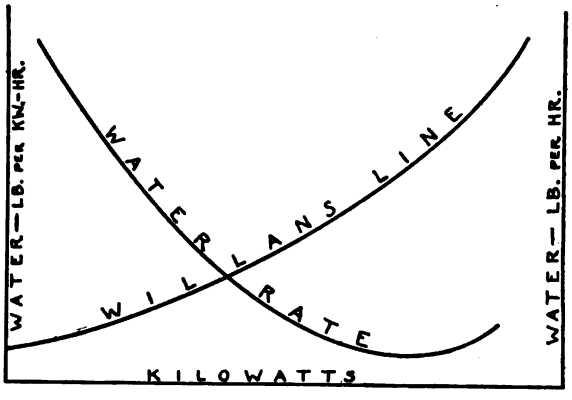


FIG. 14.

Example.— Using equations for water-rate developed in the November issue, for a 3000-kw. Curtis installation:

$$y_1 = (5.862 \div x) + 11.00 + 0.572\,x$$

$\sqrt{A \div C} = \sqrt{17.02 \div 0.156} = \sqrt{109.1} = 10.44$, or 10,440 kw., which checks the curve exactly. (Fig. 10, p. 20.)

Curtis installation, Fisk Street station, Chicago.

$$y_1 = (17.02 \div x) + 10.54 + 0.156\,x.$$

$\sqrt{A \div C} = \sqrt{17.02 \div 0.156} = \sqrt{109.1} = 10.44$, or 10,440 kw., which checks the curve exactly (Fig. 9, p. 19).

PROBLEM 2.

The Best Division of Load between Similar Engines.— As previously discussed, if the water-rate curve is $y_1 = A \div x + B + C\,x$ the curve of total water, or Willans line, is then: $y = A + B\,x + Cx^2$; where y is water in 1000 lb. per hr.; x is load in 1000 kw.; and A, B, C are constants, determined for each machine.

Let K be total load in kw. Let K_1, K_2, $K_3 \ldots K_n$, be load in kw. per machine. Let n be number of similar engines, by which is meant engines with identical water-rate curves.

Total water per hour $= A + BK_1 + CK_1^2$

$$+ A + BK_2 + CK_2^2$$

$$\ldots\ldots\ldots\ldots$$

$$+ A + BK_n + CK_n^2$$

$$= nA + B(K_1 + K_2 + \ldots . K_n) + C(K_1^2 + K_2^2 \ldots . K_n^2)$$
$$= nA + B \times K + C(K_1^2 + K_2^2 \ldots . K_n^2)$$

The last term is the only variable, and is a minimum (the sum of K_1, K_2, ... K_n being a constant = K) when $K_1 = K_2 = K_3 = K_n$.

Hence for machines with identical water-rates, the best division of load is an equal one between machines. If the term Cx^2 is zero, as for throttled-governor engines, the total water is independent of the individual loads, and one division is as good as any other.

Proof.— The sum of $(K_1^2 + K_2^2 + K_3^2 + \ldots . K_n^2)$ is a minimum when $K_1 = K_2 = K_3 = K_n$, provided that $(K_1 + K_2 + K_3 + \ldots . K_n)$ is constant.

$$(K_1^2 + K_2^2 + K_3^2 + \ldots \ldots . K_n^2) = (K_1 + K_2 + K_3 + \ldots \ldots . K_n)^2 - 2(K_1 K_2 + K_1 K_3 + K_2 K_3 + \ldots .) \ldots \ldots \ldots \ldots (1)$$

Consider the third term: $(2 K_1 K_2 + 2 K_1 K_3 + 2 K_2 K_3 + \ldots .)$.

$$= \{K_1^2 + K_2^2 - (K_1 - K_2)^2\} + \{K_1^2 + K_3^2 - (K_1 - K_3)^2\} + \ldots \ldots$$
$$= (n - 1)(K_1^2 + K_2^2 + K_3^2 + \ldots . K_n^2) - \{(K_1 - K_2)^2 + (K_1 - K_3)^2 + (K_2 - K_3)^2 + \ldots .\}$$

Substituting this value in equation (1) and transposing:

$$n(K_1^2 + K_2^2 + K_3^2 + K_n^2) = (K_1 + K_2 + K_3 + K_n)^2 + \{(K_1 - K_2)^2 \ldots \ldots\}$$

Hence, $$(K_1^2 + K_2^2 + K_3^2 + K_n^2) = \frac{1}{n}(K_1 + K_2 + K_3 + \ldots K_n)^2 + \frac{1}{n}\{(K_1 - K_2)^2 \ldots .\}$$
$$= \text{Constant} + \frac{1}{n}\{(K_1 - K_2)^2 \ldots .\}$$

The left-hand side is a minimum when the second term of the right-hand side is a minimum. When $K_1 = K_2 = K_3 = \ldots . K_n$, the right-hand side is a constant plus zero, i.e., has its minimum value.

PROBLEM 3.

The Best Division of Load between Two Dissimilar Engines.— By dissimilar engines is meant engines with water-rate curves which are not identical.

Case I, Willans Line Straight.— In this case, the equations are:

$$(y_1)_1 = A_1 + B_1 x_1 \text{ and } (y_1)_2 = A_2 + B_2 x_2$$

in which 1 and 2 represent the two engines; $x_1 + x_2 = L$ = total load; (y_1) = 1000 lb. water per hour; x = load in 1000 kw.; A and B are constants.

Total water per hour = $(y_1)_1 + (y_1)_2 = Y$

$$= A_1 + A_2 + B_1 x_1 + B_2 x_2$$
$$= A_L + B_1 (L - x_2) + B_2 x_2$$
$$= A_L + B_1 L + x_2 (B_2 - B_1)$$
$$= \text{Constant} + x_2 (B_2 - B_1)$$

This value is a minimum when second term is a minimum. Since we assume two engines are needed, and neither x_2 nor $(B_2 - B_1)$ is zero, this sum will be a minimum when x_2 is a minimum.

Hence that division is best which puts the greatest practicable share of the load on Engine No. 1, the engine having the smaller value of B in its equation.

Case II, Willans Line not Straight.—

For engine No. 1, $(y_1)_1 = A_1 + B_1 x_1 + C_1 x_1^2$

For engine No. 2, $(y_1)_2 = A_2 + B_2 x_2 + C_2 x_2^2$

where $x_1 + x_2 = L$ = total load.

Total water per hour = $(y_1)_1 + (y_1)_2 = Y$

$$= A_1 + B_1 x_1 + C_1 x_1^2 + A_2 + B_2 x_2 + C_2 x_2^2$$
$$= A_1 + A_2 + B_1 (L - x_2) + C_1 (L^2 - 2Lx_2 + x_2^2) + B_2 x_2 + C_2 x_2^2$$
$$= (A_1 + A_2 + B_1 L + C_1 L^2) + x_2 (B_2 - 2LC_1 - B_1) + x_2^2 (C_1 + C_2)$$

This is the expression for the total water per hour in terms of the load on one machine (x_2). Differentiating for minimum:

$$\frac{dY}{dx_2} = \frac{d}{dx_2}\left[\text{Constant} + (B_2 - 2C_1 L - B_1) x + (C_1 + C_2) x_2^2\right]$$
$$0 = (B_2 - 2C_1 L - B_1) + 2x_2 (C_1 + C_2)$$
$$x_2 = \frac{B_1 + 2C_1 L - B_2}{2 (C_1 + C_2)}$$
$$= \frac{B_1 - B_2}{2 (C_1 + C_2)} + \frac{C_1}{(C_1 + C_2)} \times L$$

Hence the load on engine No. 2, and consequently that on engine No. 1, are linear functions of the total load. As an example, note the curves of the engines in the 59th St. station, New York, when running in parallel, (Fig. 17).

Example: — Consider parallel operation of:

1. Fisk St. Curtis unit, $(y_1)_1 = 17.02 + 10.54\,x_1 + 0.156\,x_1^2$
2. Combined 59th St. unit $(y_1)_2 = 30.90 + 6.96\,x_2 + 0.306\,x_2^2$

$$x_2 = \frac{B_1 - B_2}{2(C_1 + C_2)} + \frac{C_1}{C_1 + C_2} \times L$$

$$= \frac{10.54 - 6.96}{2(0.156 + 0.306)} + \frac{0.156}{0.156 + 0.306} \times L$$

$$= \frac{3.58}{0.924} + \frac{0.156}{0.462} \times L$$

$$= 3.88 + 0.338\,L.$$

Total Load.	L.	Fisk St.	Combined Unit.
15,000 kw.	15	6,060 kw.	8,940 kw.
20,000	20	9,360	10,640
25,000	25	12,670	12,330
28,000	28	14,660	13,340

It will be noted that the individual loads are linear functions of the total load; these lines cross near 24,000 kw., and the Fisk St. engine would then carry a larger share than the combined unit. The division when the combined unit operates in parallel with several of the 59th St. reciprocating engines is shown graphically, in Fig. 13.

Problem 4.

To determine when an additional engine should be thrown on the line.—Consider similar machines having equations of the form: $Y = A + Bx + Cx^2$. It has been previously shown that for similar engines an equal division of load is best. Hence, total water used per hour:

For one engine, $(y_1)_1 = A + Bx_1 + Cx_1^2$

For two engines, $(y_1)_2 = 2\left[A + B\frac{x_2}{2} + C\left(\frac{x_2}{2}\right)^2\right]$

For three engines, $(y_1)_3 = 3\left[A + B\frac{x_3}{3} + C\left(\frac{x_3}{3}\right)^2\right]$

For n engines, $(y_1)_n = n\left[A + B\frac{x_n}{n} + C\left(\frac{x_n}{n}\right)^2\right]$

x_n being such a load that n engines are needed.

These curves are plotted successively in Fig. 15; at a point θ the

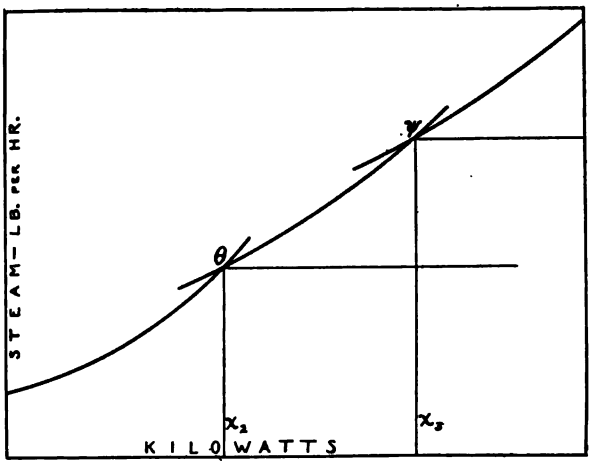


FIG. 15.

total water can be expressed in terms of one engine or two, since the load x_2 is common to both.

$$\text{Hence:}\quad A + Bx_2 + Cx_2^2 = 2\left[A + B\frac{x_2}{2} + C\left(\frac{x_2}{2}\right)^2\right]$$

$$= 2A + Bx_2 + C\frac{x_2^2}{2};\ \text{whence, } x_2 = \sqrt{2A \div C}$$

Similarly, for a third engine:

$$2\left[A + B\frac{x_3}{2} + C\left(\frac{x_3}{2}\right)^2\right] = 3\left[A + B\frac{x_3}{3} + C\left(\frac{x_3}{3}\right)^2\right]$$

$$\text{whence, } x_3 = \sqrt{6A \div C}$$

$$x_4 = \sqrt{12A \div c.} \qquad x_5 = \sqrt{20A \div c.} \qquad x_6 = \sqrt{30A \div c.}$$

$$12 = 3 \times 4 \qquad 20 = 4 \times 5 \qquad 30 = 5 \times 6$$

Hence the *n*th engine is at its highest desirable load when $x_{n+1} = \sqrt{n(n+1)\,A \div C} = \sqrt{n(n+1)}$ times the most economical load on one engine. Therefore the load at which to switch in an additional engine — the $(n+1)$th — is at: $\sqrt{n(n+1)}$ times the most economical load on one engine.

Example.— Engines in Station all Similar.— Consider the 3000-kw. Curtis unit previously discussed:

$$y_1 = 5.862 \div x + 11.00 + 0.572\,x;\ \sqrt{A \div C} = 3200 \text{ kw.}$$

Second engine in at: $\sqrt{1\times 2}\times 3200$ kw.= 4,525 kw.
Third " " " $\sqrt{2\times 3}\times 3200$ kw.= 7,850 kw.
Fourth " " " $\sqrt{3\times 4}\times 3200$ kw.= 11,100 kw.

PROBLEM 5.

Total Water used by n *Engines.*— To find the total water used up to the point when $(n+1)$th engine is switched in, each engine being thrown in at its best point: $x_{n+1} = \sqrt{n(n+1)\,A \div C}$. As before, x is load in 1000-kw., and y is water in 1000 lb. per hour.

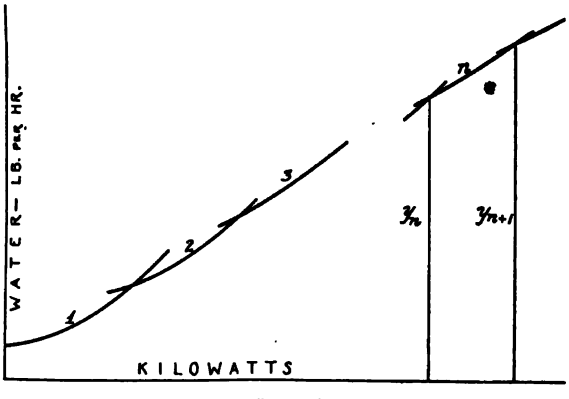


FIG. 16.

For the nth machine, $y_n = nA + Bx + Cx^2 \div n$

Area under y_n $y_{(n+1)} = \int_{x_n}^{x_{n+1}} y_n dx = \left[nAx + \frac{Bx^2}{2} + \frac{Cx^3}{3n}\right]_{x_n}^{x_{n+1}}$

$$= \left[\ldots\ldots\ldots\ldots\ldots\ldots\right]_{\sqrt{n(n-1)A\div C}}^{\sqrt{n(n+1)A\div C}}$$

$$= \left[nA\sqrt{n(n+1)\frac{A}{C}} + \frac{B}{2}n(n+1)\frac{A}{C} + \frac{C}{3n}\sqrt{n^3(n+1)^3\frac{A^3}{C^3}}\right]$$

$$- \left[nA\sqrt{n(n-1)\frac{A}{C}} + \frac{B}{2}n(n-1)\frac{A}{C} + \frac{C}{3n}\sqrt{(n-1)^3n^3\frac{A^3}{C^3}}\right]$$

$$- A\sqrt{\frac{A}{C}}\left[n\sqrt{n(n+1)} + \frac{1}{3}\frac{n(n+1)}{n}\sqrt{n(n+1)} - n\sqrt{n(n-1)}\right.$$

$$\left. - \frac{1}{3}\frac{n(n-1)}{n}\sqrt{n(n-1)}\right] + \frac{BA}{2C}\left[n(n+1) - n(n-1)\right]$$

$$= \frac{A}{3}\sqrt{\frac{A}{C}}\left[(4n+1)\sqrt{n(n+1)} - (4n-1)\sqrt{n(n-1)}\right] + \frac{BA}{2C}\left[2n\right]$$

$$= \frac{A}{3}\sqrt{\frac{A}{C}}\left[(4n+1)\sqrt{n(n+1)} - (4n-1)\sqrt{n(n-1)}\right] + n\frac{BA}{C}$$

Substitute $(n-1)$, $(n-2)$,.....3, 2, 1, for n.

$$\frac{A}{3}\sqrt{\frac{A}{C}}\left[(4n-3)\sqrt{n(n-1)} - (4n-5)\sqrt{(n-1)(n-2)}\right] + \frac{BA}{C}(n-1)$$

$$\frac{A}{3}\sqrt{\frac{A}{C}}\left[(4n-7)\sqrt{(n-1)(n-2)} - (4n-9)\sqrt{(n-2)(n-3)}\right] + \frac{BA}{C}(n-2)$$

$$\frac{A}{3}\sqrt{\frac{A}{C}}\left[(4\times 2-1)\sqrt{2\times 3} - (4\times 2-1)\sqrt{2\times 1}\right] + \frac{BA}{C}\times 2$$

$$\frac{A}{3}\sqrt{\frac{A}{C}}\left[(4\times 1-1)\sqrt{1\times 2} - 0\right] + \frac{BA}{C}\times 1$$

Total water equals the sum of these quantities, or:

$$W = \frac{A}{3}\sqrt{\frac{A}{C}}\left[(4n+1)\sqrt{n(n+1)} - 2\left(\sqrt{(n-1)n} + \sqrt{(n-1)(n-2)} + \sqrt{(n-2)(n-3)} + \sqrt{2.1}\right)\right] + \frac{BA}{C}\left[n + (n-1) + (n-2) + \ldots\ldots 1\right]$$

$$= \frac{A}{3}\sqrt{\frac{A}{C}}\left[(4n+3)\sqrt{n(n+1)} - 2\left(\sqrt{(n+1)n} + \sqrt{(n-1)n} + \sqrt{(n-1)(n-2)} \ldots\ldots + \sqrt{2\times 1}\right)\right] + \frac{BA}{C}\frac{n(n+1)}{2}$$

$$- \frac{A}{3}\sqrt{\frac{A}{C}}\left[(4n+3)\sqrt{n(n+1)} - 2\Sigma\sqrt{n(n+1)} \text{ to } n \text{ terms}\right] + \frac{BA}{2C}n(n+1)$$

For the small number of engines used in practice, the summation

term $\Sigma\sqrt{n(n+1)}$ can be best evaluated by substitution; the other terms follow directly.

Hence the total water used by n engines is:

$$W = \frac{A}{3}\sqrt{\frac{A}{C}}\left[(4n+3)\sqrt{n(n+1)} - 2\Sigma\sqrt{n(n+1)} \text{ to } n \text{ terms}\right] + \frac{BA}{2C}n(n+1).$$

PROBLEM 6.

Equation of the Willans Line through the Switch-in Points.— The total water used by n engines may be approximated if we note that, in general, the Willans line for each engine becomes almost straight after the second or third. The line through the switch-in points, then, is very closely the curve of total water, and if its equation is determined, the total water may be found.

For the point $x_{n+1}\ y_{n+1}$, at which the $(n+1)$th engine comes in,

$$y = y_{n+1} = nA + Bx + \frac{Cx^2}{n} \quad \ldots\ldots(1)$$

$$\text{and } x = x_{n+1} = \sqrt{n(n+1)\frac{A}{C}} \quad \ldots\ldots(2)$$

On the elimination of n, the resulting equation should be the locus.

Equation (1) becomes $n^2A + n(Bx - y) + Cx^2 = 0$

Equation (2) becomes $n^2A + nA - Cx^2 = 0$

By addition and subtraction, $2n^2A + n(A + \overline{Bx - y}) = 0$

or, $2nA + (A + \overline{Bx - y}) = 0$, since n is not 0,

and $n(A - \overline{Bx - y}) - 2Cx^2 = 0.$

$$\text{Whence, } -\frac{A + \overline{Bx - y}}{2A} = n = \frac{2Cx^2}{A - (Bx - y)}$$

$$-(A + \overline{Bx - y})(A - \overline{Bx - y}) = 4ACx^2$$

$$-[A^2 - (Bx - y)^2] = 4ACx^2$$

$$A^2 - (Bx - y)^2 + 4ACx^2 = 0$$

$$A^2 - B^2x^2 + 2Bxy - y^2 + 4ACx^2 = 0 \quad \ldots\ldots(4)$$

which is the locus, probably of a hyperbola.

Check the equation, using the form:

$$A^2 - (Bx - y)^2 + 4ACx^2 = 0 \quad \ldots\ldots(3)$$

When $x = 0$, $A^2 - (-y)^2 = 0$, whence $y = A$; correct.

For one engine, $n = 1$, the equation is: $y = A + Bx + Cx^2$, or $(Bx - y) = -(A + Cx^2)$

Equation (3) becomes:

$$A^2 - (A + Cx^2)^2 + 4ACx^2 = 0$$

$$(2A + Cx^2)(-Cx^2) + 4ACx^2 = 0$$

$$2A + Cx^2 - 4A = 0$$

$$Cx^2 - 2A = 0$$

$$x = \sqrt{2A \div c} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{correct.}$$

And so on.

Hence the equation: $A^2 - (Bx - y)^2 + 4ACx^2 = 0$ is the required locus of the switch-in points.

PROBLEM 7.

The Operating Schedule.— Fig. 17 illustrates the preparation of an operating schedule to obtain maximum economy. It is based on a steadily increasing load; three curves of total steam consumption are shown. Curve *B* represents the steam used when operating with the minimum number of engines; since the lost work is proportional to the number of engines in service, this looks like an economical arrangement. Curve *A* is a somewhat similar condition, but working lower on the water-rate curves. Curve *P* is based on the proportional division of load as developed earlier in this section. It is almost uniformly lower than the others.

Between 19,000 kw. and 36,500 kw., the areas under the curves are as follows:

Under *P*	744.3	sq. in.
" *A*	756.8	" "
" *B*	756.5	" "

If the load rises according to a straight-line law, in 2 hours, 1 sq. in. = $20{,}000 \times (2 \div 35)$ lb. = 1140 lb. The difference between *A* and *P* is 12.5 sq. in., or 1.65 percent.

This has assumed a proportional increase in the individual loads up to 15,500 kw. on the turbine unit, when an additional engine is thrown in. By further increasing the reciprocating output, holding the turbine output steady at 15,500 kw., a further reduction can be effected, increasing the saving to 1.8 percent.

The ladder-like diagram on the right of Fig. 17 is in two parts, and shows at a glance the appropriate load on each engine in service when any desired total load is divided for maximum economy. The station is assumed to operate two 15,000-kw. combined units in parallel with 7000-kw. reciprocating engines, six of which are available.

For one reciprocating engine: $(y_1)_1 = 36.75 \div x_1 + 0.6 + 1.85\, x_1$

For one combined unit: $(y_1)_2 = 95.5 \div x_2 - 4.25 + 0.778\, x_2$

From the formulas developed:

$$X_1 = \frac{B_2 \cdot B_1}{2\,(C_2 + C_1)} + \frac{C_2}{C_2 + C_1} \times L$$

Hence for two units and one reciprocating engine,

$$x_1 = -1.083 + 0.174\, L.$$

Similarly for two reciprocating engines, $x_1 = -1.84 + 0.296\, L$

For three	"	"	$= -2.41 + 0.387\, L$
For four	"	"	$= -2.86 + 0.458\, L$
For five	"	"	$= -3.20 + 0.513\, L$
For six	"	"	$= -3.47 + 0.557\, L$

where L is the total load in units of 1000 kw., and x_1 is the load on reciprocating engine, in the same units. Thus the loads are determined and by reference to the water-rate curves, the total steam consumption. The switching-in points are at the intersections. Thus the running schedule is derived and is reduced to a basis of one machine of each kind; it is assumed that all similar machines are similarly loaded. If the operator has any means of controlling the steam supply he can follow this schedule by watching only two meters. Alteration of the field will have no useful effect. It may change the amperes, but not the useful watts. The power output can be regulated only on the steam side.

On the left-hand side, the simultaneous reserve capacity in service for swings is shown by reading on the upper scale. Two other possible load divisions are analysed in curves *P* and *A* and plotted. The proportional division uses respectively 3 percent. and 2 percent. less steam.

4.— The Low-Pressure Steam Turbine.

The development of the low-pressure steam turbine has provided

design, however, it is not difficult to provide an effectiv

T
and
ser
om
unit
are
F
F
F:

H

Si

wher
on re
termi
consu
Thus
one m
are si
the ste
meters
change
can be
On
ice for
possibl
The pr
les

... of the low-pressure steam turbine has provided

an economical and satisfactory means of increasing a station output without any increase in boiler power. A plant may be extended by (1) duplicating existing units, (2) purchasing complete expansion turbines, (3) installing low-pressure steam turbines to utilize the exhaust already available.

This latter type of turbine is exceedingly simple; its design is simpler than that of the standard turbine. It has only half the heat drop and requires therefore only half the number of rows of blades. The volume of steam is usually large, and so substantial blade dimensions are obtainable and the turbine can operate at low speeds.

Considerations preliminary to Selection.— In each installation, certain alternatives must be considered. (1) Shall the turbine connect direct to the engine exhaust without any governor and, if so, what is the best receiver pressure between the two units? (2) If a governor is employed, shall it control the admission to the turbine, or control a by-pass from the engine to the condenser? (3) Shall a regenerator be employed; if so, how long will it be required to provide steam for the turbine to carry full load? (4) In intermittent service, in how far can the blow-off steam from the boiler be utilized? In a rolling mill, for instance, it is not customary to stop firing because the rolls stop for a few minutes. (5) To what extent may a rotary converter, or a motor generator set, be utilized to link together a direct-current reciprocating unit with an alternating-current, low-pressure steam turbine, or vice versa? (6) Should the turbine be synchronous or non-synchronous?

There are two main classes of service: (A) Steam supply intermittent and widely varying in quantity; e.g., rolling mills, steam hammers, and hoisting engines. All these involve the regenerating principle and the consideration of the time element in supply and demand. (B) Non-intermittent supply; e.g., central stations for lighting, traction, or factory drive — really a general problem of factory extension.

The turbine may be considered a third cylnder on a reciprocating engine with fixed cut-off. A careful study of the engine is necessary; if the low-pressure release is too low, large negative loops may be produced on the indicator card, which give rise to heavy "slamming" of the low-pressure valves. Should an error be made in the design, however, it is not difficult to provide an effective remedy by

a slight change in the angle of the blade. If the load has not yet reached its maximum, one or two rows of blades can be omitted from the turbine.

The useful field of the low-pressure steam turbine lies among plants with the following features: (1) Good engine design; fair operating efficiency; increased capacity necessary. (2) Inefficient engine design; condensing, or non-condensing; improved economy necessary. (3) Present condensing plant unsuitable, or inefficient. (4) Plant location such that water supply is limited, unsuitable, or costly; enforced non-condensing operation. (5) High fuel cost. For the same coal consumption, a net increase in capacity of 80 to 100 percent. is possible; the power cost reduces in the same proportion.

A good Corliss engine working with a back pressure of 15 to 20 lb. abs. has a thermodynamic efficiency of 72 percent. (Rankine cycle) where the cylinder ratio is 1 to 2.5 or 3.5. Similarly, a steam turbine expanding from 15 to 25 lb. abs. shows a maximum efficiency of 73 percent. with moderate vacuum. Hence the combined plant should have an efficiency of 65 to 75 percent. of the ideal cycle.

As regards governing, a low-pressure turbine may be either (1) electrically locked or (2) independent of the reciprocating engine.

(1) (a) Turbine takes all the steam from main engine. No governor required; turbine load varies with engine load. (b) Turbine takes part of engine steam. No governor; output constant with uniform pressure in exhaust main, due to excess of steam.

In both these cases an atmospheric relief valve and hand throttle valve should be provided.

(2) (c) Where the turbine is electrically independent of the main engine, i.e., on separate bus bars, a governor is required if the steam supply is intermittent. For momentary deficiencies, pass line steam through a reducing valve.

Results obtained in operation.—The complete success of the 59th Street, New York, installation need be only mentioned here. To date, three 7500-kw. Allis-Chalmers double horizontal-vertical compound engines have been converted into 15,000-kw. combination units by the addition of individual Curtis low-pressure steam turbines. Two more are on order. The best steam economy per kw.-

hr. has been improved from 17.1 to 13.1 lb. The net results are summarized thus by Mr. Stott.

(a) An increase of 100 percent. in maximum capacity of plant.
(b) An increase of 146 percent. in economic capacity of plant.
(c) A saving of approximately 85 percent. of condensed steam.
(d) An average improvement in economy of 15 percent. over best high-pressure turbine results.
(e) An average economy improvement of 25 percent. (between 7000 kw. and 15,000 kw.) over the best engine results.
(f) An average unit thermal efficiency of 20.6 percent.— formerly 10.3 percent.

The number of installations grows rapidly. The Brown-Boveri Company has equipped its Mannheim factory for almost exclusive manufacture of low-pressure turbines. Abroad, the regenerative principle is take up keenly.

The following are actual results obtained in commercial operation:

1.— The Scranton Street Railway was formerly equipped with four simple, non-condensing Corliss engines:

	Rated H.P.	KW.
1. Allis, 42×54 in., 97 r.p.m.	1400	1000
2. Dickson, 26×48 in., 80 r.p.m.	400	300
3. Cooper, 26×48 in., 80 r.p.m.	400	300
4. Cooper, 30×38 in., 97 r.p.m.	750	500
	2950	2100

Initial pressure, 115 lb. Engines 1 and 4, direct connected; Nos. 2 and 3, belted. Average output, 1500 kw. Maximum output taxed the entire plant, but was of short duration. Exhaust from all engines led down into common tee and thence to free outlet.

In 1906, a 500-kw. low-pressure Curtis turbine was installed, taking steam from the outlet and exhausting into a condenser. Cooling water was brought from the Lackawanna River, 450 ft. away, and lifted 54 ft. The turbine, when working between atmosphere and 28-in. vacuum, uses 38 lb. steam per kw.-hr., and delivers its full rated output, i.e., uses 20,000 lb. steam per hour. The engines at their maximum load supply 90,000 lb. per hour. There is room, then, for two or three similar units.

2.— At East St. Louis, an 800-kw. low-pressure unit is installed, driving a 500-volt, direct-current generator in parallel with the engine generators, whence it derives its steam. From the same header, steam is supplied to a 1000-kw. low-pressure turbine supplying an independent alternating-current load.

3.— The equipment of the Thirteenth and Mt. Vernon Street sta-

tion of the Philadelphia Rapid Transit Company formerly consisted of four 1500-hp. and one 2200-hp. Wetherill Corliss engines, running non-condensing, for lack of cooling water.

In 1905, a low-pressure steam turbine, 800-kw. Curtis type, was installed, with an Alberger condenser of 8000 sq. ft. Circulating pumps were direct-connected to 120-hp. interpole motor. Vacuum was 28 in. The turbine takes steam from the common exhaust header. Each 1500-hp. engine delivers about 2000 amp. at 575 volts. The steam from one engine, at this load, gives from the turbine 1300 amp. at 575 volts, with no increase in engine back pressure. The auxiliaries take 150 amp.; the net gain from the turbine is 1000 to 1200 amp. or 67 percent. Had the condenser been applied direct to the engines, the gain would have been about 25 percent.; hence the increased gain is 42 percent. The turbine generator is 6-pole, direct-current, 1200 r.p.m., without intermediate governor. Guaranteed water-rate is 36 lb. per kw.-hr. between atmosphere and 28-in. vacuum.

In 1906 a similar 800-kw. low-pressure unit was installed, with condenser and cooling tower. All the auxiliaries are motor driven, except two dry air pumps, one step-bearing pump, and two hot-well pumps. These auxiliaries take 14 percent. of the turbine output, the exhaust being turned into a feed heater.

The two turbines run 18 hours per day. In 1905 the coal consumption for all purposes was 4.48 lb. per kw.-hr. In 1906, with two turbines installed, consumption was 4.08 lb. per kw.-hr. With fuel at $3 per ton, this means a saving of $24,414 per annum. When further turbines are needed, the coal consumption will be cut down to 3 lb. per kw.-hour.

The above improvements required an outlay of capital computed as follows: The original steam equipment cost about $100 per kw., and to have duplicated along the original lines would have entailed a proportionate outlay. The low-pressure turbines were installed at a cost of $50 per kw. Further, steam energy previously wasted was now used, and without any extra fuel or attendance charges 2300 kw. could be put on the bus bars in place of the previous 1500 kw.

To recapitulate: In 1904, reciprocating engines only; 1905, one low-pressure turbine installed; 1906, two low-pressure turbines installed.

	1904.	1905.	1906.
Average kw.-hr. per month	2,475,000	2,500,000	2,957,500
" cost per kw.hr., Mills	7.3	6.9	6.03
" cost of coal per kw.hr., Mills	5.15	4.97	4.5
" pounds of coal per kw.hr.	4.6	4.47	4.08

During 1906-7 the turbines carried 16.8 percent. of the load. Comparing that year with 1904, the station delivered an increased average amount of power to the extent of 19.5 percent., or 482,500 kw.-hr. per month more; yet the total cost of the station was $216,-810 in 1904 and $214,005 in 1906; i.e., it cost $2,805 less to deliver 19.5 percent. more energy as a result of the low-pressure installation.

5.— Standard Load Curves.

A valuable application of the water-rate equation is in the determination of the relative suitability of different engines for a given service, and conversely in the determination of the service for which a particular engine is most suited. Given a curve of water-rate and a common, irregular, load curve, the total water can be calculated by the cumbersome graphical method. Were the load curve of some simple mathematical form, it would be possible quickly to reach the same result by substitution. Actual load curves never are of such a shape, but there are certain ones to which the three broad classes of practical power application conform.

1. A mill load is usually steady at definite values.

2. A railway load is fluctuating at all times, increasing and decreasing twice a day, with a maximum greatly in excess of the mean on a swing. The station at 59th Street, New York, is reported to have a load factor of 60 percent. on the peak. For the remainder of the day the mean rises and falls only slowly.

3. A lighting load has two peaks, the evening one being the greater. The fluctuations are few and the mean is very near the maximum. Extraordinary lighting loads, e.g., theatres, are better explained as railway load service. Similarly, certain mill loads.

These three types of service are paralleled by three representative load curves: 1, a point; 2, a straight line; 3, a sine wave.

1. If the load has a fixed value, we obviously are interested in the economy only at that load.

2. Since, in railway service, the load on a 5000-kw. generator may be 3500 kw. one minute and 6500 kw. the next, owing to the irregular and uncontrolable stopping and starting of trains, and a

minute later may have any other value intermediate or beyond, good economy at all loads is desirable. The generator must have a suitable overload capacity, but high economy on overload is not more desirable than at other loads. Since the area under a load curve is a measure of the total steam used on that curve, a straight line seems suitably to represent a railway load, as it emphasizes all loads equally.

3. In a lighting station for private houses and commercial firms, the maximum is little greater than the mean load over any short period. The peaks are safely carried on the overload capacity of the generators. Here then high economy is important on overload. For lighting service, a sine wave is representative, since it emphasizes the overloads.

The General Load Curve.—Standard load curves, either linear, or sine functions, can be represented by the general formula:

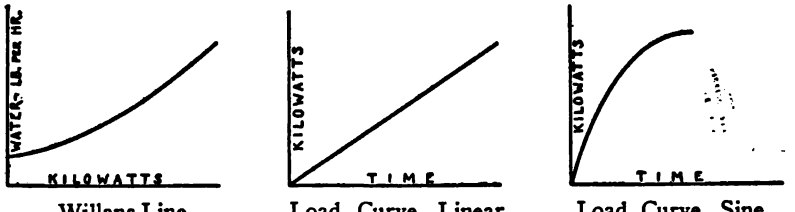
Kw. = pt + q *sin* ωt, where p or q is zero in particular cases.

Fluctuations can likewise be expressed by considering them as small sine waves, or as the *n*-th harmonics of the fundamental:

$$\text{Kw.} = pt + q \sin \omega t + r \sin n \omega t$$

Total Water used on any Load Curve.— Given relations between: (1) Water and kw., abbreviated as W and kw., and (2) Kw. and time, kw. and T, to find relation between water and time:

$W = A + B\,\text{kw.} + C\,\text{kw.}^2$



Willans Line, $y = A + Bx + Cx^2$ | Load Curve, Linear function of Time. | Load Curve, Sine function of Time.

FIG. 18.

Assuming load curve is a straight line, with zero load at beginning of time,

$$\text{Kw.} = kT \text{ and } W = A + BkT + C(kT)^2$$

$$\text{Total water, } \int_0^T WdT = AT + \frac{B}{2} k\,T^2 + \frac{Ck^2}{3} T^3$$

If the load is a simple sine function of the time, load being zero at beginning of time,

Kw. = k *sin* ωT, in which k and ω are known.

$W = A + Bk \sin \omega T + Ck^2 \sin^2 \omega T$

On integrating,

$$W = \left[AT - \frac{Bk}{\omega} \cos \omega T + \frac{Ck^2}{2}\left(T - \frac{1}{2}\frac{\sin 2\omega T}{\omega}\right)\right]_0^T$$

$$= AT - \frac{Bk}{\omega} \cos \omega T + \frac{Ck^2}{2}\left(T - \frac{1}{2}\frac{\sin 2\omega T}{\omega}\right) + \frac{Bk}{\omega}.$$

(Note that the constant, $Bk \div \omega$, is obtained by putting T = o.)

$$= \frac{Bk}{\omega} + \frac{(A + Ck^2)}{2} T - \frac{Bk}{\omega} \cos \omega T - \frac{Ck^2}{4} \frac{\sin 2\omega T}{\omega}$$

= (Straight line) + (Fundamental) + (Second harmonic).

In practice, the load on an engine does not start at zero; the integration should therefore be taken between T_1 and T_2, where T_2 is the time of maximum load and T_1 the time of lowest operating load. The formulas then become:

Linear Load Curve.—

$$W = A(T_2 - T_1) + \frac{Bk}{2}(T_2^2 - T_1^2) + \frac{Ck^2}{3}(T_2^3 - T_1^3)$$

Sine Load Curve.—

$$W = (A + \frac{Ck^2}{2})(T_2 - T_1) + \frac{Bk}{\omega}(\cos \omega T_2 - \cos \omega T_1) - \frac{Ck^2}{4\omega}(\sin 2\omega T_2 - \sin 2\omega T_1)$$

$$= (A + \frac{Ck^2}{2})(T_2 - T_1) + 2\frac{Bk}{\omega} \sin \omega \frac{T_2 - T_1}{2} \sin \omega \frac{T_2 + T_1}{2} - \frac{Ck}{2\omega} \sin \omega (T_2 - T_1) \cos \omega (T_2 + T_1)$$

Added Steam Consumption due to Fluctuation in Load Curve.—Taking the general equation of load curve as:

$$\text{Kw.} = pt + q \sin \omega t + r \sin n\omega t$$

and considering the fluctuations as *n*th harmonics of the fundamental, to find the effect of r *sin* n. ωt on steam consumption:

Assume 1-min. readings, such that one complete vibration from

mean to maximum and back to mean occurs in one minute. The equation of the harmonic is then: Kw.= r *sin* (π t).

Equation of Willans line is:

$$\text{Water per hour} = A + B\,kw + C\,kw^2$$
$$\text{Water per minute} = (A + B\,kw. + C\,kw^2) \div 60$$

$$\text{Total water} = \frac{1}{60}\int (A + Bkw. + Ckw^2)\,dkw.$$
$$= \frac{1}{60}\int \left(A + Br\ sin\ \pi t + Cr^2\ sin^2\ (\pi t)\right) dt.$$
$$= \frac{1}{60}\left[At - \frac{Br\ cos\ \pi t}{\pi} + Cr^2\left(\frac{t}{2} - \frac{sin\ \pi t\ cos\ \pi t}{2\pi}\right)\right]$$
$$= \frac{1}{60}\left[At - \frac{Br}{\pi}\ cos\ \pi t + \frac{Cr^2}{2}\ t\right]_0^1$$
$$= \frac{1}{60}\left[A + \frac{Br}{\pi} + \frac{Cr^2}{2} + \frac{Br}{\pi}\right]$$
$$= \frac{1}{60}\left[A + \frac{2Br}{\pi} + \frac{Cr^2}{2}\right]$$

If the mean load T is at the minimum point of the water-rate curve, fluctuation above or below the mean will increase the consumption by practically equal amounts for equal displacements. Hence the increase in total water for *N* minutes is:

$$\frac{N}{60}\left[A + \frac{2Br}{\pi} + \frac{Cr^2}{2}\right]$$
$$= N\left[A + \frac{2Br}{\pi} + \frac{Cr^2}{2}\right] \text{ lb. per hour}$$

Under the conditions assumed, the effect of fluctuations is to increase the steam consumption: (1) In direct proportion to their number; (2) at a greater rate than the square of their amplitude. In engines for which the Willans line is straight, C = 0; the increase is then proportional only to the first power of r — hence the desirability of a low value for C in railroad work.

Relative Merits of two Machines.— Given two engines, each of 1000 kw., having water-rate curves as follows:

$$\text{No. 1.—}\ (y_1)_1 = 4.8 \div x + 8.4 + 4x$$
$$\text{No. 2.—}\ (y_1)_2 = 9.8 \div x - 0.8 + 8.3x$$

Case 1.—Railway service; straight-line load curve. Assume that

the load increases from 500 to 1500 kw. in one hour; Kw. = kt, and k = 1.

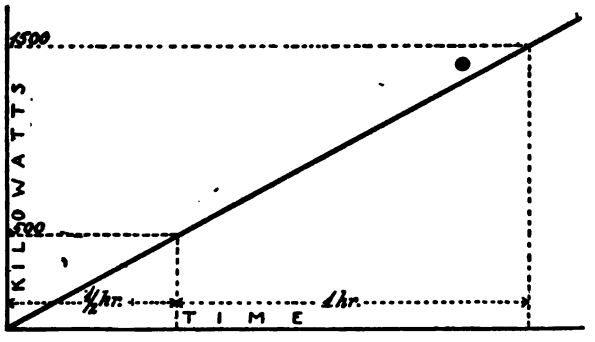


FIG. 19.

$$\text{Total Water} = A(T_2 - T_1) + \frac{Bk}{2}(T_2^2 - T_1^2) + \frac{Ck^2}{3}(T_2^3 - T_1^3)$$

$$\text{For engine No. 1, } W = 4.8 \times 1 + \frac{8.4 \times 1}{2} \times 2 + \frac{4 \times 1}{3} \times 3.25$$

$$= 4.8 + 8.4 + 4.3 = 17.5, \text{ or } 17{,}500 \text{ lb.}$$

$$\text{For engine No. 2, } W = 9.8 \times 1 - \frac{0.8 \times 1}{2} \times 2 + \frac{8.3 \times 1}{3} \times 3.25$$

$$= 9.8 - 0.8 + 9 = 18, \text{ or } 18{,}000 \text{ lb.}$$

Hence No. 1 : No. 2 = 97.3 : 100.

Case 2.— Lighting service; sine load curve. In this case, kw. = k sin ωt. At T_2 let kw. have a maximum value of 1500, starting with 500 at T_1.

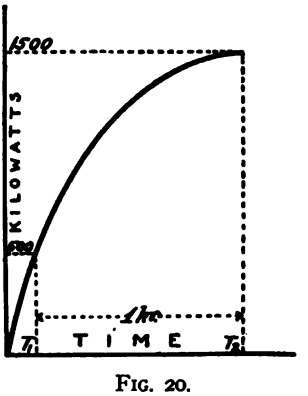


FIG. 20.

Sin ωt = 1, and k = 1.5.

At T_2, $1.5 = k \sin \omega t$,

or $1.5 = 1.5 \sin \omega t$.

At T_1, $0.5 = k \sin \omega (t - 1)$

or $0.5 = 1.5 \sin \omega (t - 1)$.

Hence, $\sin \omega t = 1$;

and $\sin \omega (t - 1) = \frac{1}{3}$.

$$\omega t = \frac{\pi}{2}; \text{ and } \omega (t - 1) = \frac{19.5}{90} \times \frac{\pi}{2} = \frac{0.217\pi}{2}$$

$$\frac{\pi}{2} \quad \omega = \frac{0.217\pi}{2}; \quad \frac{\pi(1 - 0.217)}{2} - \omega; \quad \frac{0.783\pi \times t}{2} = \frac{\pi}{2}$$

Whence, $t = \frac{1}{0.783} = 1.28$; and $\omega = \frac{0.783\pi}{2}$.

$$W = \left(A + \frac{Ck^2}{2}\right)(T_2 - T_1) + \frac{2Bk}{\omega} \sin \omega \frac{T_2 - T_1}{2} \sin \omega \frac{T_2 + T_1}{2} - \frac{Ck^2}{2\omega} \sin \omega (T_2 - T_1) \cos \omega (T_2 + T_1)$$

For comparison, consider (1) a turbine taking steam at 150-lb. gage, and 100° F. superheat, generating 1000 kw., and exhausting at 28-in. vacuum; and (2) a reciprocating engine working under the same conditions, except that the vacuum is 26 in.

$$(1)\ W = \left(4.8 + \frac{4 \times 1.5^2}{2} \times 1 + \frac{2 \times 8.4 \times 1.5 \times 7}{0.783 \times 11} \times \sin \frac{\omega}{2} \times \sin \omega \frac{2.28}{2} - \frac{4 \times 1.5^2 \times 7}{0.783 \times 22} \times \sin \omega \cos \omega \times 2.28\right)$$

$$= 9.3 + 20.45 \sin \left(\frac{0.783}{2} \times 90°\right) \sin (0.783 \times \frac{2.28}{2} \times 90°) - 3.66 \sin (0.783 \times 90°) \cos (0.783 \times 2.28 \times 90°)$$

$$= 9.3 + 20.45 \sin 35.2° \sin 80.3° - 3.66 \sin 70.4° \cos 160.6°$$

$$= 9.3 + (20.45 \times 0.57 \times 0.98) + (3.66 \times 0.94 \times 0.94)$$

$$= 9.3 + 11.42 + 3.23 = 23.95, \text{ or } 23{,}950 \text{ lb. steam.}$$

$$(2)\ W = \left(9.8 + \frac{8.3 \times 1.5^2}{2}\right) - \frac{2 \times 0.8 \times 1.5 \times 7}{0.783 \times 11} \sin \frac{\omega}{2} \sin \omega \frac{2.28}{2}$$

$$= 19.15 - 1.95 \sin \frac{\omega}{2} \sin \omega \frac{2.28}{2} - 7.59 \sin \omega \cos \omega \times 2.28$$

$$= 19.15 - (1.95 \times 0.57 \times 0.98) + (7.59 \times 0.94 \times 0.94)$$

$$= 19.15 - 1.09 + 6.71 = 24.77, \text{ or } 24{,}770 \text{ lb. steam.}$$

For lighting service, then, (1) : (2) = 96.8 : 100.

6.— Summary.

Briefly reviewing the preceding pages, it has been the object of this paper to present a new method of examining the steam cost of a generating station, a method which is at once both scientific and simple, and unlike previous standard "economies," is independent of the load factor.

Previous research has been in the direction of improving the transforming mechanism, or of perfecting the working medium; to

introduce one pound of steam into the cylinder as the vehicle for the maximum amount of heat. We have analyzed this condition and, besides the obvious practical reasons, have shown that there is a theoretical limitation to the increase of boiler pressure. Superheating, furthermore, adds little to the thermo-dynamic efficiency, though practically it has many marked advantages.

At the exhaust end of the cycle, it has been attempted to reduce the amount of heat rejected to the condenser, but while theoretically the efficiency increases without limit with decrease of back pressure, practically the cost quickly becomes excessive.

The exhaust-steam turbine completely displaces the reciprocating engine as a means of utilizing steam at very low pressures. The economies that can be effected by its use in certain cases are, at least, surprising. In the 59th Street, New York, station the efficiency of transformation has been raised from 10.3 to 20.6 per-cent. In one plant where the writer had the opportunity to suggest its use, the low-pressure turbine will completely pay for itself in six years.

None of these economies, however, is available for a station operating on a poor load factor. They all require the investment of capital, and where the load factor is low, fixed charges must be kept at the minimum.

From a number of tests on engines typical of modern practice—steam turbines, Parsons and Curtis types, Corliss engines of both large and small sizes, and combination units—it has been shown that where the tests are properly conducted, the water-rate points group themselves along a smooth mathematical curve of the form: $y_1 = A \div x + B + C\,x$, where y_1 is water in pounds per kw.-hr.; x is load in kw.; and A, B, C. are constants appropriate to each engine.

This equation has a convenient form, and by a few simple transformations, some important relations can be obtained.

Quite independent of the yearly load factor, whenever two engines are run in parallel, there is an opportunity to effect economy by the proper proportioning of the load between them. If the engines are alike, the division is a simple one; if they are dissimilar, the relation is according to a law that has been determined, but the relation once established, the division is linear and equally simple. By solving the water-rate equation for a minimum, the most econ-

omical load is obtained; by multiplying both sides by the load in kw., the equation of the Willans line is derived. When n machines are running, it has been shown that the Willans line for the nth engine is: $y_n = nA + B\,x_n + C\,x_n^2 \div n$.

By eliminating y between the equations for the nth engine and the $(n+1)$th, the value of x is obtained, indicating the point at which it is most economical to throw in the latter engine.

Therefore for a station with a load increasing or decreasing, the suitable switching points for successive engines can be determined. and thence an operating schedule derived which will give the required output for the least steam and coal. Where other operating conditions prevail, the difference in total steam can be readily exhibited graphically as in Fig. 17, on which two other possible methods of division are plotted against the proportional division. Thus the engineer can have before him an ideal operating schedule — an ideal, not like the Rankine cycle, desirable but unattainable, but one capable of very complete realization in certain cases.

The water-rate equation has an interest for the prospective purchaser. Certain simple mathematical load curves have been proposed as standards of reference. Should they prove acceptable, with their aid the water-rate equation will enable a customer to analyze a mass of otherwise conflicting and confusing guarantees, and to select that engine best suited to his service.

The development of the high-economy steam turbine has demanded this analysis. Present plants are being extended by adding steam turbines; low-pressure turbines are being installed and combination units formed to operate in parallel with existing engines. As the number of such "mixed" stations tends to increase, so will the value of such an analysis as this become greater, being based on the equations of the water-rate curves of the individual units.

MANUFACTURE OF RAW SUGAR IN THE PHILIPPINE AND HAWAIIAN ISLANDS.*

BY C. A. BROWNE.†

It was my pleasure a year ago to address the students of this course upon the chemistry of raw-sugar production. That paper was published in the SCHOOL OF MINES QUARTERLY, of April, 1911, and to save time and prevent repetition I will simply refer you to it for a description of the cane and beet sugar industry, and for statistics upon sugar in general. As a subject for this year, it occurred to me that a brief account of the methods of producing sugar in some of our colonial possessions would be of interest. I have therefore selected the Philippine Islands, where agricultural and technical methods are still very primitive, and the Hawaiian Islands, where the processes are among the best in the world.

The sugar from the Hawaiian Islands and the Philippines is mostly exported to the United States, where it is refined. A great deal of the Hawaiian sugar is shipped to San Francisco, the nearest American port; the rest of it comes to the eastern ports, principally Philadelphia, by way of the Isthmus of Tehuantepec, where it is transported in trains across Mexico to the Gulf, and reshipped. The Philippine sugar is shipped mostly to New York and comes, for the most part, by way of the Suez canal and the Mediterranean, an occasional shipload coming by way of Panama or around Cape Horn.

It will be seen from the map that the cane producing countries are situated, for the most part, each side of the equator between the Tropics of Cancer and Capricorn. At one time the cane grew only in India, from which country its cultivation spread eastward and westward. Ancient Chinese writings mention the introduction of cane into China several centuries B. C.; its cultivation was extended eastward by the Malayan and Polynesian tribes to the East Indies, the Philippines, the Pacific Islands, and finally to Hawaii, where it was found growing when these islands were discovered.

SUGAR PRODUCTION IN THE PHILIPPINES.

We will now look first at the agricultural side of the Philippine

* A special lecture in the Department of Chemistry.

† Chemist in charge, New York Sugar Trade laboratory, 80 South Street, New York.

sugar industry. Fig. 1 represents the preparation of the soil before planting the cane. The beast of burden used almost wholly in the Philippines is the carabao, a kind of native ox, very savage in the wild state, but easily domesticated. The plows are made of wood and are of very primitive workmanship.

FIG. 1. PLOWING IN THE PHILIPPINES.

FIG. 2. PLANTING CANE, PHILIPPINES.

After the ground is prepared, parallel furrows are plowed across the fields and into these furrows the cane tops, which serve as seed, are planted. The nature of the seed and the method of planting are shown in Fig. 2.

After the cane-tops are planted and covered with earth, the buds quickly germinate and the young cane plants soon appear above the ground. The crop is cultivated by plowing and hoeing until the rainy season begins, when the cane is left until the time of harvest, which is usually 9 to 14 months from the time of planting.

When the sugar cane is harvested, the ground is not usually replowed, but the old stubble is left, from the underground buds of which a second crop of cane, known as stubble or "ratoon" cane, is produced. In the Philippines, from two to eight ratoon crops are taken off before the land is plowed up and replanted. Ratooning saves the labor and expense of planting, but the continuous growing of the same crop year after year without replowing is a heavy drain upon the fertility of the land; long ratooning, for this reason, is not followed in the most progressive countries.

The harvesting of sugar cane is done by hand in all countries. Inventors have spent years and fortunes in trying to perfect machines which would cut the cane stalks close to the ground, strip them of their leaves and tops and gather them into bundles, after the plan of a wheat harvester. They have not as yet succeeded. A sugar cane field at the time of harvest is almost a jungle; stalks are intertwined and blown down by the wind so that the cutting and trimming of each cane is a separate problem, for which hand labor seems to be the only solution. (Fig. 3.)

The green tops of the canes, containing the leaves and buds, are of no use for making sugar, but are exceedingly valuable as seed. The tops are saved and the leaves removed by husking, much in the same way as ears of corn are husked. This part of the work is done by women and children.

After the stalks of cane have been cut and loaded upon wagons, they are hauled to the factory and unloaded preparatory to the grinding. Fig. 4 shows a typical Philippine sugar house with its open sides and low roof and chimney.

The grinding of sugar cane in the Philippines is performed in some places by antiquated steam engines and in some places by the still more primitive method of using oxen. In the photograph of an ox-driven mill (Fig. 5) the two animals are attached to sweeps upon opposite sides; the sweeps are connected with a vertical shaft which operates the rollers of the mill by means of a bevel gear. The

cane juice escapes from the mill through a small gutter and flows to the evaporator, where it is boiled into sugar. The extractive power of these mills is very low, and usually less than ¾ of the sugar in the cane is expressed. The pressed cane, or bagasse, constitutes the principal supply of fuel, but as it contains a large amount of unexpressed juice, it must first be dried before it can be burned. The drying is carried out by spreading in the sun in open yards.

The evaporation of the juice in the Philippines is carried out in open pans or kettles (Fig. 6) which are set in large fire-places, heated by burning bagasse. The juice from the mill is first strained through a screen, to remove suspended impurities, into the first pan of the evaporator. The pans are usually arranged in two series of five, which open into one another at the top; each succeeding pan as shown in the photograph is slightly smaller in size, but higher in elevation, the arrangement being step-like in appearance. In the first pan the juice is warmed to 70 or 80° C.; a little lime is added and the coagulated impurities skimmed off into scum tanks which are placed at an elevation upon one side. The common utensil for skimming and ladling is an old kerosene can, attached to a pole. It is interesting to know that the kerosene can in some parts of the Philippines is the standard measure of volume.

The hot juice is ladled from the first into the second pan of the evaporator, the general plan being always to keep the smaller pans full, so that scums, when boiling over, will discharge backwards into the preceding vessel. More lime is also added, usually half a cocoanut shell full at a time, according to the judgment of the sugar maker. The plan is to keep the juice always slightly acid; the sugar maker relies for this upon color, smell, and taste, the use of litmus or other indicator being generally unknown.

As the juice is ladled from pan to pan it becomes more and more concentrated and in the last pan becomes sufficiently thick to crystallize. When this point is reached, as is determined by taking out a sample of the product upon a stick, the contents of the pan are ladled onto wooden trays and shoveled with a spade until the mass sets to a thick material resembling concrete. The crystallization, which is attended by the liberation of considerable heat, requires from 15 min. to an hour, according to the grade of sugar. The sugar made in this way contains, of course, all the impurities

of the juice except those removed by the scums. There is consequently no molasses as in processes wherein the sugar is purged. The concrete is then ground up and packed in wicker mats holding about 50 pounds.

Most of the sugar made by this method of manufacture is classified by color into grades. The lightest, or first grade, polarizes

FIG. 3. LOADING CANE IN FIELD, PHILIPPINES.

FIG. 4. DISCHARGING CANE AT FACTORY, PHILIPPINES.

about 88°; the second grade polarizes about 86°; the third grade polarizes from 82 to 84°; a fourth, very dark grade of mat sugar polarizing 80° or below is also marketed occasionally. The darkening in color of the product is due either to over liming or to burning in the kettles; there is a curious belief among natives that

boiling the sugar at night will cause the sugar to become tinged with darkness, thus lowering its grade.

The sugar after leaving the factory is transported by small boats to Iloilo or Manila, where it is stored for shipment to this country.

FIG. 5. CANE MILL, PHILIPPINES.

FIG. 6. OPEN PAN EVAPORATORS, PHILIPPINES.

Fig. 7 shows the method of discharging mats at Iloilo. Sugar which has been damaged by water from leaky boats or by rain is spread out upon trays to dry in the sun, as shown in the foreground.

Only about 55 percent. of the sucrose in the cane is obtained as raw sugar by the primitive methods of manufacture carried on in

the Philippines; 25 percent. of the sugar is lost in the bagasse; the remaining 20 percent. represents the loss in the scums, and the sugar destroyed by inversion, caramelization, and in other ways.

Attempts are being made at present by the Philippine authorities to improve the methods of sugar manufacture. Herbert Walker, a

FIG. 7. UNLOADING MATS OF SUGAR, PHILIPPINES.

FIG. 8. TRAVELLING LABORATORY, PHILIPPINES.

young chemist to whom I am indebted for these photographs, spent many months visiting the plantations of the island of Negros, carrying with him a polariscope and other apparatus, studying methods of sugar manufacture, and wherever possible suggesting methods of improvement. The photograph (Fig. 8) of one of Mr. Walker's

portable pioneer laboratories shows the meeting place of the old and the new order of things; the polariscope and other up-to-date apparatus is set up in a bamboo hut.

As an indication of what the new order of things is destined to accomplish, it is worth mentioning that on Feb. 21, 1912, a modern sugar factory equipped with the latest machinery, mills, evaporators, vacuum pans, centrifugals, and crystallizers, began its operation. The first output of this factory was a sugar polarizing 98.2°, the highest grade of plantation sugar manufactured in the Philippines up to that time. Other central sugar factories are being erected, and it may be stated with confidence that in those islands, where the sugar content of the juices reaches over 18 percent., with a purity exceeding 90 percent., the future outlook is most promising.

Sugar Production in the Hawaiian Islands.

Passing now to our other possession in the Pacific, the Hawaiian Islands, we shall see what the sugar industry in the Philippines must aspire to. Fifty years ago the methods of cultivation and manufacture were as primitive as those just noted in the Philippines. With the establishment of reciprocity with the Hawaiian Islands in 1875, by which Hawaiian sugar was admitted into the United States free of duty, a great impetus was given to the industry by the influx of American capital. This impetus was still more intensified by the annexation of the Islands to the United States in 1898.

Sugar cane thrives most luxuriantly in the Hawaiian Islands and the growth of cane is also promoted by superior methods of cultivation and irrigation. A yield of 12 tons of sugar per acre of land has been obtained, whereas 50 years ago not more than one ton of sugar could be obtained from that area. The production of sugar per acre will probably average about four times as much as in the Philippines, although if we figure the ratio per acre per year, the proportion will be reduced nearly one-half.

Sugar cane is cultivated in the Hawaiian Islands for the most part upon table lands which slope downward towards the coast. The factories, for convenience in shipping and receiving supplies, are usually situated near the coast, very often upon high headlands, as shown in Fig. 9. You will notice the large streams of water

which flow down the bluff in the form of cascades; this is not only the waste water of the sugar factory but much of it comes from the flumes and waterways by which the cane is transported to the factory.

The land is prepared for the cane crop in Hawaii by means of

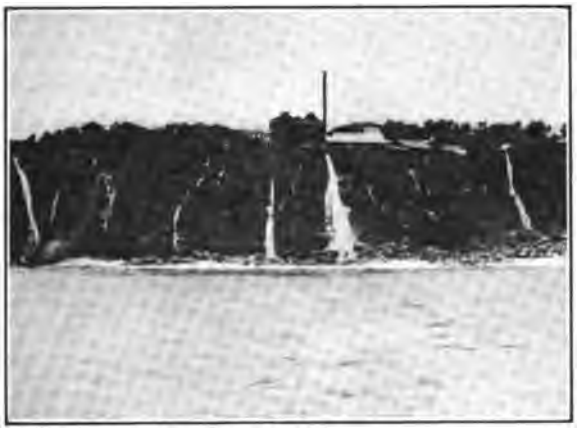


FIG. 9. SUGAR FACTORY, HAWAII.

FIG. 10. STEAM PLOW, HAWAII.

large plows which are drawn by engines and cables across the fields. The method of operation is shown in Fig. 10. The plow shown turns four furrows at one operation, and is reversible; the plow beam carries eight shares, only four of which are in operation at

one time, the remaining four being elevated as shown. The plow is drawn by a cable stretched between drums upon two traction engines on opposite sides of the field; the plow is drawn back and forth between the two engines, the beam being tilted one side down in

FIG. 11. SORTING CANE TOPS FOR SEED, HAWAII.

FIG. 12. PUTTING CANE INTO FLUME, HAWAII.

one direction, and the other side down in the other. The plowing scene in the Philippines (Fig. 1) may be more picturesque than this, but as regards efficiency and economy of labor there is no comparison between the two.

Much of the work done in the cane fields of the Hawaiian Islands is performed by labor-saving devices of a high order. A great deal of the work must however be done by hand; the planting of the cane is all hand work, so also the husking of the cane tops for seed by native and Japanese labor, as shown in Fig. 11, which is very similar to the same operation in the Philippines.

After planting the tops and covering with earth, the cane fields are usually irrigated, and as the young cane begins to develop, cultivation is resorted to, very much as in the large corn fields of our Western states. "Ratooning" is never carried beyond one year; the field is then replowed for a new crop of cane.

The sugar cane in the Hawaiian Islands is usually allowed to reach its maximum development, and the crop is frequently not harvested until 22 months after planting. This long period of growth, nearly two years, favors, of course, a large crop of cane, but the return of sugar per acre, to be compared with countries which cut the cane yearly, must of course be divided by two.

The cane stalks are cut and trimmed by hand and then transported to the factory which is frequently many miles distant. A most ingenious method of transporting cane in some of the Hawaiian Islands is by means of flumes, which, starting as open troughs in the upper cane fields, are carried down to join other sluiceways until there is finally a small river of water carrying with it a tangled mass of cane stalks. The cane as fast as cut is carried to the nearest sluice, where it is thrown, stalk by stalk, into the running water; the starting of a cane stalk upon its long journey is shown in Fig. 12.

Owing to the liability of the stalks to become entangled in the flumes and thus stop the movement of the cane, the waterways are patrolled by men who keep the sluiceways clear. Fig. 13 shows a guard walking between two flumes, the one empty and the other filled with moving cane stalks flowing toward the front of the picture.

In some places the flumes span wide ravines several hundred feet in depth, as shown in Fig. 14. The trestle supporting this flume is built entirely of wood and speaks well for the engineering accomplishments of the carpenter.

Fig. 15 shows the ending of a flume at the sugar factory. The

cane stalks are discharged from above into railroad cars, the excess of water escaping through the bottom and forming one of those numerous streams seen falling down the cliff into the sea in Fig. 9.

The question is frequently raised whether this long contact of the cane stalks with running water does not wash out a considerable amount of sugar. Mr. Walker, to whom I am also indebted for the Hawaiian views, informed me that after evaporating many liters of flume water, and applying the very delicate α-naphthol test with H_2SO_4, only the faintest coloration developed, and a calculation to the original volume of flume water showed that the losses from this cause were almost negligible. This is what would be expected. There is of course a very slight loss of sugar from the ruptured cells at the cut ends of the stalk, but nothing can escape from the uninjured tissues. The fluming process really improves the cane, for the water removes adhering dirt and trash which would otherwise find its way into the juice.

FIG. 14. TRESTLE SUPPORTING CANE FLUME, HAWAII.

The mills for grinding sugar cane in the Hawaiian Islands are the most powerful in the world. Fig. 16 shows in the distance two heavy rollers with corrugated iron surfaces; this part of the mill, which first receives the cane from the conveyer, is called the crusher; it reduces the cane stalks to an even pulpy blanket of fiber and at the same time removes from 50 to 60 percent. of the juice. The blanket of pulp is next carried between other rollers which are arranged in sets of three, two below and one above. These constitute the mill proper, and according to the degree of extraction desired there are six-roller mills, nine-roller mills, twelve-roller mills, and even fifteen-roller mills, the entire plant being thus made

of detachable mills of three rollers each. The extracting power of each mill is increased by powerful hydraulic presses; to increase further the extraction of sugar the blanket of fiber between each two sets of rollers is sprayed with fine jets of water which is delivered

FIG. 13. CANE CONVEYING FLUME, HAWAII.

FIG. 15. DISCHARGING CANE FROM FLUME, HAWAII.

from transverse sprinkling pipes shown in the photograph. This water is absorbed by the fiber and being again squeezed out by the next rollers carries with it more of the sugar-containing juice, which is of course considerably diluted by the wetting. The very dilute juice from the last mill is sometimes used instead of water for

spraying the fiber from the first mill. This process of wetting and repressing is called "maceration" and it requires careful calculation and good management to know just when the evaporation of the added water begins to cost more than the value of the extra sugar recovered. The cost of fuel, labor, and many other factors, all have to be considered and a system of maceration which is profitable in one country might be ruinous elsewhere. In the Hawaiian Islands 30 percent. or more of water is sprinkled upon the ground cane, and with the large mills which are employed, over 95 percent. and in some cases over 97 percent. of the total sugar in the cane is extracted. These figures, compared with the 70 and 75 percent. extraction obtained in the Philippines, show what possibilities there are for improvement in the latter islands.

The juice, after extraction, is clarified with lime and sulphurous acid, and the impurities of the hot juice removed in powerful filter presses. The clarified juice is then concentrated in vacuum evaporators to a syrup, which is further concentrated in a vacuum pan to a thick mass of crystals. Fig. 17 shows a view of the vacuum pans at the Ewa plantation in the Hawaiian Islands.

The graining of the sugar in the vacuum pans, the centrifugal separation of the molasses, and the drying and bagging of the sugar, are carried out essentially as described in the paper already referred to.*

The sugar, after it has been bagged, is conveyed to ships for transportation to the United States. If the factory is located in the interior, the sugar is carried down to the coast by rail or by means of traction engines, which, as shown in Fig. 18, transport many wagon loads of sugar at one haul.

If the factory is located upon a headland near the sea, the sugar is run down to the ship upon cables, as shown in Fig. 19.

Commercial Problems of the Sugar Trade.

The transportation of sugar from the Philippines and Hawaiian Islands, and the marketing of the commodity, present a number of problems in which the chemist is more or less directly concerned.

There is first the question of deterioration. Moist sugar is very susceptible to fermentation and the fumes from a cargo of

* The Quarterly, April, 1911.

sweating sugar after the ship has been in the tropics is almost overpowering. A moist sugar testing 88° at Manila or Iloilo may polarize only 86° when it arrives at its destination, and the owner of the sugar usually lays the blame upon the chemist or the transportation company rather than upon himself. The Hawaiian manufacturers dry their sugar, and their product, as regards deterioration, always arrives in as sound condition as when placed upon ship.

A second question, which is always arising, is the damage to the sugar during shipment. This damage results mostly from wetting and may happen in several ways. The seepage of sea water into the hold of an old freight boat may damage seriously the bags of sugar resting upon the bottom of the ship, especially if the ship owners are too parsimonious to employ dunnage for the protection of the cargo. Damage to sugar by salt water must usually be paid by the owners of the ship, and a chemist is sometimes confronted with the problem of determining whether a given lot of sugar is damaged by salt or by fresh water. The problem is not as easy as it might seem at first sight.

The damage to sugar by fresh water usually results from sweating; in such cases the top bags in the hold usually suffer the damage. The vapors from the lower tiers of warm sugar condense upon the roof of the hold and dropping back, wet the upper sacks of sugar, very much like a shower of rain. If it is all one owner's sugar, it makes, of course, little difference; one part of his sugar has dried out a little and another part has become correspondingly more moist. But when this moisture falls back upon some other owner's sugar, complications arise.

The breaking of bags during transport is also a frequent occurrence. The damage to Hawaiian sugar in transporting across the Isthmus of Tehuantepec is sometimes considerable. Bags are also broken on the ship and at the dock in discharging the cargo. Sugar lost in this way is called loose sugar; as much as possible of it is saved and it is classified as Mexican loose, ship loose, or dock loose, as the case may be. It is not always easy to determine to what owner the loose sugar belongs; it may be apportioned according to the proportionate ownership of the cargo or in other ways, according to agreement. The amount of sugar damaged in shipment varies greatly. Of a cargo of about 100,000 bags of Hawaiian

sugar recently tested in our laboratory, there were about 1000 bags, or 1 percent., damaged by fresh water; over 300 bags of Mexican loose, and over 100 bags of dock and ship loose sugar. With the opening of the Panama canal, and direct communication between

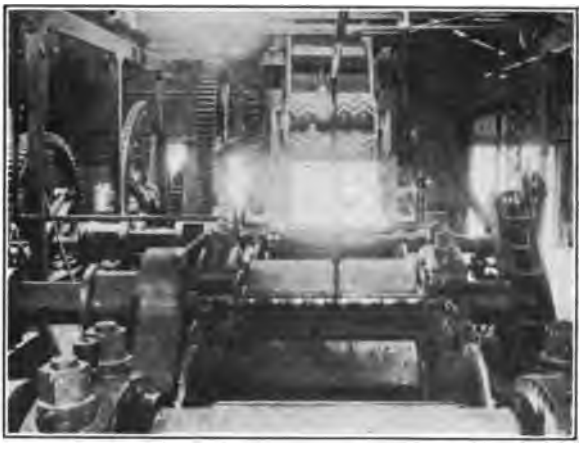


FIG. 16. CANE CRUSHER, ETC., HAWAII.

FIG. 17. VACUUM PANS, ETC., HAWAII.

Honolulu and the eastern parts of this country, we may look for a great improvement in certain matters of transportation.

The valuation of a cargo of sugar after it arrives is a most important question. The value of raw cane sugar is determined by means of the polariscope, according to familiar practice. The method of sampling the cargo may, however, be less familiar.

The need for carefully prescribed rules in sampling sugar becomes very evident when we take into account the very frequent variations in composition between sugar in different parts of the bag or mat. The sugar, for example, may contain lumps of higher or lower

FIG. 18. HAULING SUGAR, HAWAII.

FIG. 19. LOADING SUGAR TRANSPORTS, HAWAII.

polarization than the finer part of the product; the sugar may also retain considerable amounts of molasses, sometimes as high as 30 percent., which drain during transit or storage and form the "foots" at the bottom of the bag. In addition to the differences

in composition of sugar within the single bag or mat are the differences in composition between different packages of the same lot.

Sugar is sampled in the same way as fertilizers and many other commodities, by means of a trier. This implement consists of a long pointed rod of steel with a groove or spoon upon one side. A thrust of the trier into the package forces the sugar along its pathway tightly into the bowl of the spoon; the sugar thus adhering, after the trier is withdrawn, is removed by the thumb, or by means of a scraper, into a covered bucket, and the process is continued until a sufficient number of packages have been sampled to constitute a mix; this number may vary according to the size of lot and kind of sugar from one package to several thousand. The practice of the New York Sugar Trade is to mix twice daily, and in no case is a sample to remain unmixed over night.

After the sugar in the bucket has been well mixed the cans which are to be sent to the chemists are filled, sealed and labeled. When the returns of the chemists come in, an average is made and the result taken as the polarization of the sugar for the number of bags and weight of sugar represented in the sample.

Many tricks were once used in the sampling of sugar, and the sampler, by skillful manipulation of his trier and from the knowledge gained by experience, could draw sugar from the dry or wet part of the bag according to the interests of the party for which he was working.

To eliminate so far as possible the errors of personal equation in sampling, the practice of the New York Sugar Trade is for the samplers of buyer and seller to work alternately hour by hour; the one party in the interval of rest exercising a control upon the operations of the other. The tendencies to draw too high and too low from the package are thus counterbalanced and the personal errors equalized. This method seems as good as any that can be devised.

From this very hasty and very superficial review of but a limited part of the sugar industry of the world, you may perhaps have gained some idea of the enormous breadth of the field. Each individual country and each particular phase of the industry presents special problems which are constantly engaging the attention of experts and specialists.

A SYSTEM OF MINE ACCOUNTS.

BY MASON T. ADAMS.*

The object of mine accounting is the preparation, at regular intervals, of various reports and statements which will give to the owners and managers of the property information in regard to operations. To be of value, such reports and statements must be accurate, must be obtained promptly at the end of the period covered, and must give information in sufficient detail to show where losses are occurring. These reports must be arrived at in some fairly simple way, without unnecessary labor or expense.

It may be said at the outset that an absolutely accurate statement of costs in detail is an impossibility, and the more detailed is such a statement, the more of an approximation does it become. A report can, therefore, err on the side of having too much detail. How far to go in the dissection of expenditures is a matter of individual judgment for the man in charge of operations. There is certainly a point, however, beyond which any further dissection is a waste of time and too much of an approximation to give any information of value.

Since, at the best, many items entering into the statements are approximations, the accuracy of such statements will depend on the men doing the work. The first requisite for any system of mine accounts is a good accountant. The larger the operation, the more clerical help he will need. The two principal items of mine expenditure are labor and supplies. Where operations are conducted on a large scale, the distribution of these items will come from timekeepers and storekeepers. In a small operation, however, a large clerical force is not warranted, and a great deal of the detail information must come from the foremen or shift bosses. These men, as a rule, are not capable of making out detailed reports, and the burden of clerical work put on such men should be very light, and, as far as possible, all red tape should be avoided.

A summary of a general system is here given, with specimen forms. This system is in use in a lead-zinc mine, but can be adapted to any mining operation.

* Consulting Mining Engineer, 45 Broadway, New York. E. M., Columbia, 1902.

For the distribution of labor, an individual pay sheet similar to form No. 1 is used. These sheets take the place of the payroll, and each man working on the property on day's work has a sheet for each month. On this sheet are shown the hours worked, and this

AMERICAN MINES OPERATING COMPANY.
PAY SHEET.

Name .....

Occupation .....*Rate*.....*per*.....*hrs.*

Check No..... *Month of*.....19.... *No*.....

Day	Hours	Distribution						
1								
2								
3								
—								
31								
Total Hrs.								
Total Amt.								

.....*days @*.....$.....

Less Mdse .....

" *Board* .....

" *Hospital* .....

" .....

Net Amount Due .....

Received from American Mines Operating Company the above amount, wages in full for month of.....19...

Name.....

FORM NO. 1.

time is distributed directly on the sheet to the departments, each day. These sheets are kept in the main office, and are filled out from information given by the foremen or timekeepers; they are totaled and a report is given the manager, showing the labor cost in each department every day.

In case of much contract work on the property, a pay sheet similar to form No. 2 is used filled out at the end of the month from information given by the engineers or other responsible officials.

This sheet is made out to show the amount due the different partners in the contract, in case the contract is let to more than one individual, and is added to the company time sheets, to give the total payroll for the month. The men are paid off by check, drawn on a payroll account at the bank, to which is deposited each month the exact amount necessary. If men are discharged, or paid off before

AMERICAN MINES OPERATING COMPANY.
CONTRACTORS' PAY SHEET.

Contractors .....
Place .....
Distribution .....
Month of .....19....
Contract No.....
Check Nos.....

.....Feet @		$.....	
Less Laborers' Time.....			
" Powder & Supplies.....			
"		.....	
	Net Amount Due.....		
Name of Individual Contractor.....	.....	.....	.....
Amount Due	.....	.....	.....
Less Board	.....	.....	.....
" Mdse.	.....	.....	.....
" Hospital	.....	.....	.....
"	.....	.....	.....
Total Deductions	.....	.....	.....
Balance Due	.....	.....	.....
Total Balance Due on Contract		.....	

Received from the American Mines Operating Co., the above amounts set under our names, being full amount due on contract for month of.....19..

Names.....
.....
.....
.....

FORM NO. 2.

pay day, they are given a time check on the company store, and these checks are taken up at the end of the month out of the payroll account. By this method, the net payroll shows on the voucher record as one check only, deposited to the payroll account, and a large number of individual checks on the voucher record is avoided.

Supplies should be ordered on some regular form, made out in duplicate, a copy being kept in the mine office to check against receipt and payment of goods. Supplies are usually bought in quantity at different prices at different times of the year. Such supplies are carried in stock and are charged out against operations as they are used. To obtain an average price at which these supplies will be charged out, a card catalogue should be kept on a form similar to No. 3. A card is given to each article, showing prices,

Section.....

Bin.....

Article ..... Unit ..... Shelf.....

Date	From	Price	Discount	Freight		Net	Average	Received	Used	On Hand

FORM NO. 3—Printed on Card for Catalogue.

including freight, with an average cost brought forward. It also shows the amounts received and used, with the balance on hand, as a guide in ordering supplies. This balance on hand should be checked by an inventory once a year.

Where supplies are bought and go in total directly into the work of some department in a particular month, they may be charged out directly to this department on the voucher record, when the bill is paid, but where no distribution is possible at once, they are charged to a supply account or "Stores." The stocks will be kept at the mine or mill and issued from the storehouse only on an order from some responsible official, showing in what department the material is to be used. These orders are entered each day in a supply ledger on some form similar to No. 4. These ledger sheets are preferably loose-leaf, and a sheet is given each department; it will show the main supply items used in the work, the prices for supplies being taken from the card catalogue. A report for the manager is made

	Elevat Part			Total
3				
To				

	Suspense Accounts				
Boarding House	ance	Supplies	Petty Cash		

Meta	et ue	Advances	Balance Due
Pounds Zin			

out each day from this ledger, showing the supply cost by departments.

If the labor pay sheets, the supply card catalogue, and supply ledger are kept up regularly, the daily clerical work involved is not large and the total figures are immediately available for reports at any time.

In addition to daily reports on labor and supplies, the manager should receive a daily report of operations, showing the mill hours run, the causes of shut downs, the assays, the amount of product made and shipped, the tons mined and milled, etc. The figures for this report should come into the office on regular forms from the officials in charge of the different operations.

In paying the bills of the company, a voucher check system is recommended, on a form similar to No. 5. This insures that receipts for all payments come back through the bank, while the clerical work each month is lessened. As checks are drawn they are entered in a voucher record similar to form No. 6, and the totals from this record are put through the journal each month and posted in the main ledger. This record represents all payments, with the exception of any small cash expenses, which are carried in a petty-cash book. The principal receipts of the company will be from sales of ore, concentrates or metal. Shipments are recorded in a book on a form similar to No. 7, and the totals are entered in the main ledger each month.

The voucher record and the shipment record represent cash transactions which could be posted directly into the ledger without a journal. A journal, however, is necessary to take care of entries which must appear in the ledger but do not show in either of the two records. The principal journal entries necessary each month are:

1. A charge to the various operations for the supplies used from stock, taken from the supply ledger.

2. A credit to the boarding house and hospital operations of any amount deducted from the men's pay, with a charge to the various operations in addition to the charges shown on the voucher record under the net payroll.

3. A redistribution of power and similar costs under the various departments, if this is considered necessary.

VOUCHER CHECK.

AMERICAN MINES OPERATING COMPANY.

Notice: The endorsement of this voucher by payee is receipt in full for the within account.

No.....

Denver, Colo.,.....191..

Pay to the order of.....$.....

.....*Dollars.*

To First National Bank, Denver, Colo.

AMERICAN MINES OPERATING COMPANY

.....

Treasurer

..... FOLD .....

Please make all endorsements below.

(Reverse Side)

VOUCHER CHECK

Do not detach any part of this voucher.

AMERICAN MINES OPERATING COMPANY

Leadville, Colo. TO.....

Address .....

Date		Amount	Distribution	
			Number	Amount

Correct | *Approved for Payment*

FORM NO. 5

4. A monthly charge to operations from any suspense accounts. For example, taxes and insurance may be paid in lump sums for the year. These payments should not appear on the cost sheet of any one month, but should be put in a suspense account and charged out proportionally each month.

5. A charge to the various operations of any money expended from petty cash.

If there are many operating accounts, it will simplify the main ledger to carry these as one account under "Operations," and carry the distribution of this account under the various headings in a sub-ledger, preferably of loose leaf type. The main ledger, in addition to the operating accounts, will show the capital accounts, such as capital stock, value of property, plant, etc.

No attempt will be made here to discuss what should be charged to capital and what to operating accounts, but as a general rule it may be said that, once the property is on an operating basis, charges to capital accounts should be avoided so far as possible. Given a mine with proved ore, its value increases with the construction work necessary to remove and market this ore, but as soon as ore is actually being extracted, the assets of the company are in a continual state of liquidation. Too frequently, after operations have begun, construction work, often largely in the nature of renewals, is charged to capital accounts, and the book value of the assets of the company is being continually enlarged. Not only should increase in these book values be avoided, but some definite amount should be written off each year to depreciation of plant and property. Theoretically, at the end of the life of a mine, the books of the company should show no assets.

A trial balance will be taken from the main ledger and sub-ledger each month, and a comparison of operating accounts, from month to month, will show the true cost for the period. A comparison of receipts, however, does not necessarily represent the true receipts to compare with the costs for arriving at a monthly profit or loss figure. If shipments are made to a smelter, returns on the shipments made in any one month can never be received in time for the monthly report; hence an estimate must be made of the value of the product actually shipped. The form of this monthly report varies with practically every mine. One form is given under No.

8. What is wanted is a report which will show the operations for the month in sufficient detail to give the management information as to where losses are occurring, and why. On the form given are tabulated the tonnage and assay figures, with a profit and loss statement, showing the estimated value of products made, and the actual cost, by departments.

A comparison of these statements from month to month shows where costs are being increased or decreased. If the change is in supply costs, these are still further dissected, in an accompanying table. This monthly report also shows development work done and its cost, a cash statement of actual receipts and disbursements, for the month, and a statement showing the quick assets of the company and the current liabilities. Figures for this report are taken from the trial balances, the payroll, the supply records, and the various shipment, tonnage, assay records, etc., of the company. Such a report can be prepared very promptly, if the previous work has been systematized and kept up regularly.

AMERICAN MINES OPERATING COMPANY.

Report for Month ending.....19...

Tonnages:			
Tons in Stopes last month			.....
Tons mined this month			.....
Total			.....
Less Tons Milled	.....		
" " Crude Ore shipped	.....		
Balance on hand in Stopes this month			.....
Products Made:			
Tons Zinc Concentrates			.....
Tons Lead Concentrates			.....
Tons 1st class Middlings			.....
Tons 2nd class Middlings			.....
Tons Crude Zinc Ore			.....
Tons Crude Lead Ore			.....
Assays:	Oz. Ag.	% Pb	% Zn
Ore Milled	.....	.....	.....
Zinc Concentrates	.....	.....	.....
Lead Concentrates	.....	.....	.....
1st class Middlings	.....	.....	.....
2nd class Middlings	.....	.....	.....
Crude Zinc Ore	.....	.....	.....
Crude Lead Ore	.....	.....	.....
Mill Recovery:	Exclusive of Middlings		Including Middlings
Silver	.....		.....
Lead	.....		.....
Zinc	.....		.....

FORM NO. 8

Shipments:	Tons Paid for this Month	Tons in Transit
Zinc Concentrates	.....	.....
Lead Concentrates	.....	.....
1st class Middlings	.....	.....
2nd class Middlings	.....	.....
Crude Zinc Ore	.....	.....
Crude Lead Ore	.....	.....

Average Metal Quotations:

Silver	.....
Lead	.....
Zinc	.....

Cost and Profit Sheet.

Department	Labor	Supplies	Miscellaneous	Total	Per ton Trammed from Mine	Per ton handled per Department
Products Made:						
Zinc Concentrates	.....	.....	.....	.....	.....	.....
Lead Concentrates	.....	.....	.....	.....	.....	.....
1st class Middlings	.....	.....	.....	.....	.....	.....
2nd class Middlings	.....	.....	.....	.....	.....	.....
Crude Zinc Ore	.....	.....	.....	.....	.....	.....
Crude Lead Ore	.....	.....	.....	.....	.....	.....
Total Products	.....	.....	.....	.....	.....	.....
Development:						
Drifts	.....	.....	.....	.....	.....	.....
Cross-cuts	.....	.....	.....	.....	.....	.....
Raises	.....	.....	.....	.....	.....	.....
Sinking	.....	.....	.....	.....	.....	.....
Miscellaneous	.....	.....	.....	.....	.....	.....
Mining:						
Ore Breaking	.....	.....	.....	.....	.....	.....
Timbering	.....	.....	.....	.....	.....	.....
Hoisting	.....	.....	.....	.....	.....	.....
Tramming	.....	.....	.....	.....	.....	.....
Pumping	.....	.....	.....	.....	.....	.....
Miscellaneous	.....	.....	.....	.....	.....	.....
Surface:						
Tramway	.....	.....	.....	.....	.....	.....
Miscellaneous	.....	.....	.....	.....	.....	.....
Milling:						
Crushing	.....	.....	.....	.....	.....	.....
Screening	.....	.....	.....	.....	.....	.....
Jigging	.....	.....	.....	.....	.....	.....
Tables	.....	.....	.....	.....	.....	.....
Elevators	.....	.....	.....	.....	.....	.....
Heating Plant	.....	.....	.....	.....	.....	.....
Miscellaneous	.....	.....	.....	.....	.....	.....
Marketing:						
Hauling	.....	.....	.....	.....	.....	.....
Freight	.....	.....	.....	.....	.....	.....

FORM NO. 8.— (*Continued*)

General:						
Management						
Office						
Laboratory						
Surveying & Engineering						
Taxes						
Insurance						
Interest and Exchange						
Boarding House						
Miscellaneous						
Total Operations						
Profit on Operations						
Constructions:						
Total Constructions						
Net Profit						

Remarks .....

.....

.....

.....

.....

.....

Development

Department	Cost	Feet Driven	Cost per foot
Drifts			
Cross-cuts			
Raises			
Sinking			
Miscellaneous			
Total			

Estimated Ore Reserves this Month..... .....
" " " last " ....

Remarks .....

.....

.....

.....

Supplies.

On hand last month .....
Added to stock this month .....
Total .....
Used from stock this month .....
Balance on hand this month.....

FORM NO. 8.— (*Continued*)

Supply Costs per Ton.

Supplies	Development	Mining	Surface	Milling	Miscellaneous	Total
Powder, Fuse and Caps.	.....	.....	.....	.....	.....	.....
Steel	.....	.....	.....	.....	.....	.....
Tools	.....	.....	.....	.....	.....	.....
Timber	.....	.....	.....	.....	.....	.....
Pipe	.....	.....	.....	.....	.....	.....
Rails and Spikes	.....	.....	.....	.....	.....	.....
Oils and Lubricants ...	.....	.....	.....	.....	.....	.....
Mine Car Parts	.....	.....	.....	.....	.....	.....
Pump Parts	.....	.....	.....	.....	.....	.....
Hoist Parts	.....	.....	.....	.....	.....	.....
Drill Parts	.....	.....	.....	.....	.....	.....
Tramway Parts	.....	.....	.....	.....	.....	.....
Electric Parts	.....	.....	.....	.....	.....	.....
Crusher Parts	.....	.....	.....	.....	.....	.....
Roll Parts	.....	.....	.....	.....	.....	.....
Jig Parts	.....	.....	.....	.....	.....	.....
Table Parts	.....	.....	.....	.....	.....	.....
Screens	.....	.....	.....	.....	.....	.....
Elevator Parts	.....	.....	.....	.....	.....	.....
Coal	.....	.....	.....	.....	.....	.....
Office Supplies	.....	.....	.....	.....	.....	.....
Laboratory Supplies ...	.....	.....	.....	.....	.....	.....
Engineering Supplies ..	.....	.....	.....	.....	.....	.....
Miscellaneous Supplies.	.....	.....	.....	.....	.....	.....
Water	.....	.....	.....	.....	.....	.....
Power	.....	.....	.....	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....

Cash Statement.

Receipts:

Crude Ore Sold and Settled for .....
Zinc Concentrates, do .....
Lead Concentrates, do .....
Middlings, do .....
Received from Home Office .....
Miscellaneous .....
Total Receipts ....

Expenses:

Disbursed by Mine Office .....
Sent to Home Office ....
Excess of .....over ....
Balance on hand last month .....
Balance on hand this month .....

Statement of Indebtedness.

Assets:

Ore and Concentrates in transit ....
Miscellaneous Bills Receivable ....
Total Assets ....

FORM NO. 8.— (*Continued*)

Liabilities:

Labor and Supplies charged to operations but not yet paid for ....
Miscellaneous Bills Payable ....
Total Liabilities ....

Remarks .....
.....
.....
.....

FORM NO. 8 (*Concluded*)

NOTES ON BORE-HOLE SURVEYING.

BY SIDNEY L. WISE.*

It is not my purpose to discuss the many methods in use for determining the dips and lateral deviations in bore-holes, but simply to give a concise outline of the obstacles encountered and the results obtained in a recent survey of a series of holes. These were drilled at various inclinations in order to intersect the supposed continuation of a lense of pyrrhotite and chalcopyrite, the orebody following closely the foliations of the country rock. The lense dips at an angle of about 66°, and the fact that there is also a pitch to the orebody renders the pointing of the boreholes of considerable importance, to avoid missing the lense.

The country rock may be briefly described as a micaceous and sometimes garnetiferous schist, although the encountering of a hornblende gneiss is by no means rare.

The difficulty encountered in rotating the drill rods was one indication that the holes were not straight, and it was therefore decided to survey them. Due to the magnetic properties of pyrrhotite, compass methods were out of the question, but it was decided to determine the variations of dip by the hydrofluoric acid etching method.

For holes of over 600 ft. depth, the regular drill rods were employed to lower the acid bottles into the holes, while for shallower holes a heavy copper wire, mounted on a reel, was used for the lowering. The etching agent was a mixture of concentrated hydrofluoric acid and water. For shallow holes, one part of acid to two parts of water were used, but for deep holes one part of acid to four parts of water were employed. In the former case, 20 min. were allowed for etching, whereas it required 70 min. to procure a clear etching when using the weaker mixture.

The etching solution was placed in a bottle of the kind used for homeopathic medicines. This bottle was selected because of its uniform interior and exterior diameters, and because of its strength. The bottles were corked very tightly by rubber stoppers, and then were placed in cylindrical steel containers of the following general design.

Each container is made in two parts, which have respectively a male and female thread. This threading is very close, and rubber

* E. M., Columbia, 1911. Engineer for the Vermont Copper Co., So. Strafford, Vt.

gaskets are used to prevent water from leaking into the container. Trouble was experienced from this cause, due to the great hydraulic head to which a container is subjected when down 600 ft. or more. The inside of the container is cylindrical and is just large enough to contain the bottle. If water leaks into the container the pressure may be great enough to break the glass bottle inside. On the outside of each end of the container is a thread, which can be screwed into the drilling rods. The outside diameter is the same as that of the rods used, which insures that the container will lie in the true course of the hole. The length of the container, including threaded ends, is 1 ft. By placing containers between rods, at intervals, etchings were taken simultaneously at four successive 100-ft. spaces. The etching appears as a thin translucent line on the inside of the bottle.

Previous experience has shown that the angle obtained by reading the etching is not the true angle of the hole at the corresponding point. Capillary attraction causes the liquid to climb up higher on the upper side of the bottle than on the lower side. This causes the etched line to indicate a steeper dip than the actual, and hence a negative correction is necessary for every reading. Laboratory experiments show that the capillary attraction varies with the dip of the bottle. They further show that the maximum attraction takes place at about 45°, with a constant increase in the necessary correction from 0° to 45°, and a constant decrease from 45° to 90°. The correction when the bottle is inclined at 45° is about 8°. The capillary attraction also varies with the strength of the solution as well as with the diameter of the bottle, and it is therefore necessary to make the laboratory test under conditions as close as possible to those occurring in actual surveying.

The following results of a survey of one of the holes may be of interest, as it shows a remarkable flattening of the hole during diamond drilling, using the customary, rigid, steel rods:

Depth in Feet.	Corrected Dip of Hole.	Depth in Feet.	Corrected Dip of Hole.
100	56° 40′	600	32° 20′
200	53 40	700	31 15
300	49 45	800	29 15
400	41 50	900	20 30
500	36 50	1000	26 40

This hole was started with a dip of 61° 30′ and it is interesting to note that at a depth of 1000 ft. the hole was inclined only 26° 40′ with the horizontal.

ELECTRICITY IN ANTHRACITE MINING.*

BY WILLIAM PAUL JENNINGS.†

Anthracite mining is becoming more complicated every day. The output is increasing rapidly while the resources are decreasing; hence you can imagine the difficulty of keeping up a profitable operation of the anthracite mines on an increasing scale. The problem to be solved relates to the mining of small seams. The time has come when the operators in the anthracite fields must mine the small seams, and the expense of mining them by the same methods used in the larger seams is so high as to demand special study and continuous experimentation with new methods.

The general practice has been to mine by hand or to drill the holes by hand and blast the coal off the solid. But during the last two or three years we have introduced undercutting machines into the anthracite coal fields, for the purpose of mining the small seams and producing the coal at a profit. The method of mining with coal

ANTHRACITE UNDERCUTTER BEGINNING A CUT.

cutting machines is no doubt familiar, as a great deal has been written about them especially in connection with the soft coal regions. But the coal cutting machine in the anthracite region is something

* Impromptu address before the Senior Mining Society, Nov. 15, 1912.
† Mine Inspector, Pennsylvania Coal Co., Pittston, Pa.

new. It was always considered impossible to cut anthracite coal with a machine, but recently such machines have been introduced and manufacturers of them have been working on the problem with success. They have at last produced a machine which will cut anthracite coal.

Considering the enormous amount of coal mined, and the waste incurred by shooting the coal off the solid in hand mining, there is room for great saving by mining with the undercutting machine. We have made some very elaborate tests at some of our collieries, and we find that by mining the coal with the undercutting machines

ANTHRACITE UNDERCUTTER FINISHING A CUT.

we save 10 percent. of the product which was formerly lost by being shot back along the roadways and into the gobs when it was blasted off the solid. We are also able to mine it a few cents cheaper per ton. Taking the total production of anthracite coal and figuring how much 10 percent. of it would amount to, assuming that we waste that proportion, the importance of the saving made possible by the undercutting machine becomes evident.

Of course we must consider the difference in methods of mining between the Lackawanna and Wyoming valley and the Schuylkill regions. The Lackawanna and Wyoming seams are practically flat,

while in the Schuylkill regions they have pitching seams. It is probable that mining in the pitching seams will be continued as it always has been.

We find that the solution of the problem in the anthracite coal fields, for the reasons I have just mentioned, is gradually driving the companies into specialization. A great many of the corporations employ several special investigators, some mining engineers and some practical experienced men, to work on the different problems, experimenting with them and trying to produce results.

We also encounter at the present time, and it is growing more serious every day, the question of labor. We are beginning to

ARRANGEMENT FOR PROPELLING ANTHRACITE UNDERCUTTER

realize that the labor problem in the anthracite fields is one that requires good executive ability to handle. I do not mean that we are short of labor. We have plenty of labor, but the English speaking class is practically leaving the mines. We are almost entirely dependent upon foreign miners. Down in our region we have Italians, Russians, Poles, Slavs, and a few other European nationalities. They are good workmen, but their lack of knowledge of our language requires a foreman to have good executive ability to handle these men and produce the required results, especially under the changing conditions introduced by the mining of thin seams.

Electricity was introduced in the anthracite coal fields for transportation service by the Hillside Coal and Iron Company in 1886. The Lackawanna company is using electricity on a very extended scale. The power is so pliable that it is well applicable for mining purposes. The field for electrical engineers in the anthracite districts is almost as variable as for mining engineers. The new undercutting machines are run by electricity. In connection with undercutting machines in the small seams we are introducing conveyors which are run by electricity; we pump water by electricity, and also hoist and haul coal on the inside. In some of the collieries of our company, at which we produce 80,000 tons of coal in one month, we have not a single mule on the property. All the power used to handle the coal on the inside is electricity.

We are compelled by the anthracite mine law to make all our structures in the mine fireproof. In order to protect the lives of the workmen we have adopted concrete for all the inside buildings. Mule barns are all built absolutely fireproof; also our inside hospitals, and engine houses, while most of the timber work at the foot of the shafts is now replaced with concrete.

ANNUAL REPORTS.

THE PRESIDENT'S REPORT.

The following extracts from the report of President Butler, issued Nov. 4, 1912, relate to the engineering schools:

Gifts.— Among the gifts of money received by the University during the year ended June 30, 1912, totalling $2,175,177, were the following: $50,000 from Mr. and Mrs. William R. Peters, to establish a research fund in engineering in memory of their son; $15,000 from an anonymous donor for the equipment of a research laboratory in electro-mechanics; and $10,000 from Mr. Charles H. Davis, '87, for advanced instruction in research and highway engineering.

What the University most needs is gifts that will aid it in doing better the work which it has already undertaken, and not gifts which compel it to assume new obligations that in turn make an additional drain upon its already overtaxed resources. Many of those who make gifts to a university really put upon the university the new obligation of acting, without compensation, as their trustees or executors for the purpose of carrying out some plan or purpose of their own. An examination of the gifts made to American universities during a period of years would probably indicate that many persons of means desire to use a university for some purpose of their own rather than to help it carry on the work for which it is established. Gifts for general endowment, for needed buildings or equipment, or for the support of work already in progress and insufficiently sustained, really help a university to serve the purpose for which it exists. Gifts for new and designated purposes may or may not help a university.

Admission to Schools of Engineering.— The most important act of the year was the final approval by the Trustees of the policy brought forward by the Faculty of Applied Science and concurred in by the University Council, regarding the future relation of the work in the Schools of Mines, Engineering and Chemistry to the work done in Columbia College and in other colleges of similar standing. For many years these technical schools have admitted students directly from the secondary school on substantially the same basis as is fixed for admission to Columbia College. The student on leaving the secondary school has, therefore, been confronted by the alternative of entering Columbia College or of going at once into a four-year course distinctly professional and technical in character. The college trained student who wishes to prepare himself for life in one of the schools under the jurisdiction of the Faculty of Applied Science found himself in immediate association with students younger and less broadly trained than himself. This situation has not been one which the Faculty has preferred or chosen, but rather one that has been forced upon it by circumstances. It is believed, however, that the time is now approaching when admission to the Schools of Mines, Engineering and Chemistry may with wisdom be restricted to such students as have had the same amount and kind of preparation that is exacted at Columbia of intending students of medicine. This preparation may be had by two years of study in Columbia College, or in some other college or scientific school of equal standing.

By the terms of the action now taken, on and after July 1, 1914, admission to these Schools will be restricted to those who have had the training above described. It is to be presumed that the effect of this change will be to reduce considerably the enrolment under the Faculty of Applied Science, but it may be predicted with even greater certainty that the result will also be to put Columbia in position to train a still higher and better equipped type of engineer and chemist than heretofore. The Faculty is unanimous in the belief that the step taken is a wise one.

(A detailed statement of the curriculum devised to carry out the provisions of this act of the Trustees will be found in the April issue. — ED.)

Degree of Doctor of Engineering.— In my judgment an almost essential part of this educational plan is the adoption of the recommendations that have been made by the Faculties of Applied Science, with the approval of the University Council, to establish the degree of Doctor of Engineering for advanced and research work in that field. If we are to cut away students at the bottom, we must make appropriate provision for those at the top. The provision which the Faculties desire and which there is reason to believe that the students desire, is the institution of research degrees in engineering, having value and significance similar to those which ought to attach to the degree of Doctor of Philosophy. There is undoubtedly a feeling among the active practitioners of engineering that these research degrees are unnecessary and unwise. This feeling seems, however, to leave out of account the actual facts as they present themselves in the daily administration of the University. It is doubtless true that men ought to be willing to follow a course of training for its own sake without any regard to the reward or decoration to which it leads, but it is equally true that constituted as human nature now is they will not do so. It would be quite possible to extend the scope of the degree of Doctor of Philosophy so as to include the kind of instruction and research which it is proposed to offer to candidates for the degree of Doctor of Engineering, but if this were done the inappropriateness of the title as a reward for such work would soon become apparent.

The objection that to follow the recommendation of the Faculty would be to turn out a body of men holding a high degree who had never had practical experience in their profession, does not seem to me quite relevant. These degrees are not intended to cover practical experience, although perhaps the plan for them might be extended so as to make some provision for this. The holder of the degree of Doctor of Philosophy is not often very much of a philosopher, but then no one supposes that he is or need be. The same would be true of the holder of a degree of Doctor of Engineering as soon as that title had become familiar. This degree would not signify that those who received it were superlatively learned in engineering, but simply that they had had a certain definite period of training of an advanced kind and that they had shown a certain sort of power to carry on inquiry and investigation which universities the world over usually reward with the degree of doctor.

REPORT OF THE DEAN.

(*Extract from Report for Academic Year Ending June 30, 1912.*)

One of the most significant and encouraging signs of progress in the Schools of Mines, Engineering and Chemistry is the marked improvement in the scholarship of our students as shown by statistics of the past half decade. For purposes of comparison, the following figures for 1906-1907 and 1911-1912 are given here:

FEBRUARY, 1907.

	Failures					Number of Failures	Number of Students	Number without Failures	Number of Failures per Student	Percentage of Students with Failures
	Entrance	First Year	Second Year	Third Year	Fourth Year					
Freshmen	283	176	6	....	....	465	136	16	3.42	88%
Sophomores .	144	207	110	....	....	461	161	8	2.87	95%
Juniors	104	126	302	38	....	570	117	23	4.87	80%
Seniors	36	42	100	184	36	398	88	35	4.52	60%
Total	567	551	518	222	36	1894	502	82	3.77+	83%

FEBRUARY, 1912.

	Failures					Number of Failures	Number of Students	Number without Failures	Number of Failures per Student	Percentage of Students with Failures
	Entrance	First Year	Second Year	Third Year	Fourth Year					
Freshmen ...	50	101	2	....	....	153	132	75	1.15	47%
Sophomores .	18	37	50	5	....	110	144	82	.76	44%
Juniors	14	12	107	119	9	261	167	81	1.56	51%
Seniors	5	4	30	50	58	147	124	70	1.18	39%
Total	87	154	189	174	67	671	567	308	1.18	45%

NOTE.—The total number of students does not include Special students or students in the College who are exercising the engineering option.

An analysis of these figures is very interesting. It will be seen that the number of entrance conditions alone fell from 567 for 502 students in 1906-07 to 87 for 567 students in 1911-12, and the total number of failures fell during the five years from 1894 to 671, or from 3.77 failures per student in 1906-07 to 1.18 failures per student in 1911-12. Whereas in the former year 83 percent. of all the students in the Schools had one or more failures, this proportion has now been reduced to 45 percent. There is still much room for improvement, but the satisfactory showing of the first and second-year classes indicates clearly that this is sure to come about. That these records accurately reflect

actual conditions is shown by the testimony of the instructors, who commend most highly the quality of work done by the students during the past year and state that no greater seriousness of purpose nor better attitude toward their work could be expected. These results are due to a careful elimination of unsatisfactory students, to the plan of dividing classes into small sections in the first and second years (a policy which must be extended to the third and fourth years as well) to the system of academic advisers, to an increasing firmness in the administration of reasonable regulations looking toward the maintenance of high academic standards and, above all, to efficient and interested instruction, with a corresponding and persistent strengthening of the various courses offered by the Schools.

While the number of new students annually entering the Schools of Mines, Engineering and Chemistry is much larger than it was five years ago, it is obvious that the policy of raising standards by elimination of poor students is not conducive to the retention of large numbers, as about 150 students are dropped or are compelled to withdraw each year. This year's Freshman class alone was reduced from 184 to 132 at the end of the first term. Our Faculty, however, is a unit in placing quality before quantity and, fortunately for our Schools, the President and Trustees feel no less strongly than we do on that subject. There can be no doubt that our Alumni are of the same conviction.

DEPARTMENT OF CHEMISTRY.

(*Extracts from Report of Head of Department for Year* 1911-12.)

General.— With the removal of the Department of Architecture, the sixth and seventh floors of Havemeyer Hall have become available for the use of the Department of Chemistry. The sixth floor will accommodate the work in inorganic chemistry, including qualitative analysis. Through the timely munificence of Dr. William H. Nichols, President of the General Chemical Company, who has given $30,000 for the purpose, the means for fitting up the new laboratories have been secured. The two end laboratories will be used for the large classes, and the six smaller ones, by subdivision of the largest, will give ten rooms for research laboratories for instructors, assistants and graduate students. In fitting up the large laboratories, special attention has been given to the following points: (1) Each working space is provided with accommodations for the apparatus of five students, working in as many sections. (2) Each student will have upon his desk a ventilating device and a sink with hot and cold water, and, in a drawer, all the chemicals required for the course. The purpose of these arrangements is to enable the student to carry on his work with a minimum of running about, and to render unnecessary the use of any apparatus or furniture (such as hoods) by several students in common, a practise which leads to waste, to breakage for which no one is responsible, and to unsightly conditions.

The stock and supply room will be established on the seventh floor, to which access will be had by a passenger elevator. On this floor a complete supply of ordinary chemicals and apparatus will be maintained.

Here the equipment for special work and research, for loan to the instructors and students, will be kept. On this floor, also, a shop for repairing apparatus, and for cleaning glassware will be established.

In 1911, the transfer of the courses in assaying to the Department of Metallurgy was finally accomplished. The rooms on the first floor thus released, together with the large room on the same floor, recently occupied by the work in elementary inorganic chemistry, have been turned over to chemical engineering.

At the request of President Geo. A. Soper, a room was placed at the disposal of the Metropolitan Sewerage Commission of New York City for carrying on important investigations in sanitary chemistry. While the new building of the Harriman Research Laboratory of experimental medicine has been in process of construction, certain members of their staff have been accommodated in Havermeyer Hall. This arrangement has been mutually advantageous and agreeable.

Much of the attention of the officers of the department was given to a study of the requirements for advanced degrees in chemistry, in this and other universities. The departmental regulations had placed certain sections of this department at a disadvantage as compared with others, and the precise standard for the department as a whole was in need of clearer definition. The revised regulations will be found in the new *Announcement of the Division of Chemistry* for 1912-13. The chief features of the regulations are: the establishment of a specific under-graduate requirement, which must be met before any work can be counted as qualifying for the A.M. or Ph.D. degrees; and the fixing of a standard for the degree of Ph.D., which hereafter will, in general, require a period of residence and study of at least three years.

The staff of the department has been greatly strengthened by the additional instructors and the substitution of instructors for assistants in several instances. These changes involve the abolishing of four assistantships, and the creation of seven instructorships.

The Chandler Museum.— The Trustees have provided for the creation of a new position, namely that of Curator. The duties of this position concern the arrangement, care, and more systematic utilization of the valuable collections in the museum. To fill this position Thomas Bruce Freas, A.B., Ph.D., Curator and Instructor in Chemistry in the University of Chicago, was appointed, with the rank of Assistant Professor of Chemistry, and the title of Curator of the Chandler Museum. His duties include the Curatorship of the whole laboratory. Arrangements have been made to begin at once an improvement in the classification, cataloguing, and arrangement of the contents of the museum. In this connection Prof. Chandler has agreed to supervise the preparation of a complete statement of the character and history of the various exhibits. This information, which he alone can give, will be of inestimable value in the use of the contents of the museum by instructors and students.

Aside from a number of smaller gifts, the museum has received several important additions. From the Union Sulphur Co., large specimens of Louisiana sulphur; from the E. I. Dupont de Nemours Powder Co., a case of high explosives, a case of blasting supplies, and a case of blast-

ing, sporting and military powders. To Dr. H. C. Humphreys, the museum owes a collection of specimens illustrating the manufacture of starch and glucose. From Dr. Alois von Isakovics, proprietor of the Synfleur Scientific Laboratories, Monticello, N. Y., we have received 52 samples of fine synthetic perfumes.

Inorganic Chemistry and Qualitative Analysis.— After learning the routine and theory of chemical analysis, a chemist requires training in the modes of experimentation and of measurement (not of an analytical kind) which are available in chemical work. To meet this situation, a new course in experimental inorganic chemistry has been inaugurated and has been given by Prof. Freas. In 1912-13 the scope of the course will be enlarged, and a new instructor, Frederick Barry, M.A., Ph.D., will share in the work.

An attempt to teach qualitative analysis from the modern standpoint, with only entrance chemistry or an elementary college course as preparation therefor, involves considerable difficulties both for teacher and pupil. Arrangements have therefore been made for offering to Columbia College students a laboratory course in inorganic chemistry, with experimentally illustrated class-room exercises. This is a sequel to entrance chemistry, and antecedent to the courses in qualitative analysis, organic chemistry and industrial chemistry. It will be given by Dr. Barry. The numbers of students taking elementary inorganic chemistry having greatly increased, and the attendance on the college course in qualitative analysis having doubled since last year, a new laboratory assistant, P. C. Haeseler was appointed, and Mr. Salathe was transferred from other work. The staff is still too small, the work having been carried on successfully this year only at the cost of considerable personal sacrifices by the members of the staff concerned.

Dr. J. E. Zanetti, who has been for three years instructor in this section of the department, leaves to become Director of the Institute of Industrial Chemistry of Uraguay, at Montevideo. In him the department loses a valuable member and, upon his departure to a wider field of usefulness, he has the most hearty good wishes of his colleagues. His work in qualitative analysis has been taken over by Robert H. Lombard, who has since been appointed to the vacant instructorship.

Arthur Edgar, M.S., Ph.D., has been appointed to fill a new instructorship. His duties will be in connection with the course in qualitative analysis. Paul C. Haeseler has been appointed assistant in chemistry to take the place of Mr. Milliken, who has resigned.

Analytical Chemistry.— On account of the large number of students taking courses in this department, temporary accommodations have been provided for 20 men in the qualitative laboratory. A number of graduate students have been carrying on research work during the year.

At the beginning of the second half year a new instructorship in analytical chemistry was established, and Andrew Bender, A.B., was appointed to the position. For the year 1912-13, an instructorship has been substituted for the assistantship, occupied during the year 1911-12 by H. M. Bach. Dr. C. H. Jouet this year resigns his instructorship, and Robert M. Isham has been appointed in his place.

Industrial and Engineering Chemistry.— Professor Whitaker spent the greater part of the summer in Europe studying the industrial laboratory equipment of the leading technical schools in Germany and England, in order to form a basis for the development of our new laboratory of engineering chemistry. Dr. Kress arranged to spend some weeks during the summer in the leading paper mills, textile mills, tanneries and other factories in his field of instruction.

The Industrial Fellowship established by the American Brake Shoe and Foundry Co., was awarded to Carl Haner, Jr., and his researches are still under way. The Goldschmidt Fellowship in chemistry for the year 1912-1913 was awarded to John S. Bates, who will undertake the investigation of problems connected with the manufacture of paper and pulp. The new instructorship in engineering chemistry will be filled by R. K. Murphy, Chem. Eng.

Many of the changes connected with the transfer of the industrial laboratory from the second floor to the lower floors of Havermeyer Hall have been completed. The old assay laboratory has been entirely renovated and converted into a textile and paper laboratory. A large amount of additional equipment has been installed for instruction purposes and for research work in these subjects. Another portion of the laboratory has been divided into private laboratories and fully equipped with the necessary facilities for undertaking industrial research problems. The coat room has been removed to University Hall in order to provide the necessary space for the rearrangement and equipment of additional research rooms, and a laboratory for a continuation of the researches in gas manufacture. The greater portion of the equipment for the general laboratory of industrial and engineering chemistry has been purchased and delivered and the erection of this machinery is now nearly completed.

ALEXANDER SMITH.

DEPARTMENT OF CIVIL ENGINEERING.

(*Extracts from Annual Report of Head of Department for Year* 1911-12.)

The subjects of study covered in the first three years of the course, including the summer work in surveying, have all been adimnistered with efficiency and with satisfactory results. In the main this work has shown no essential changes from the preceding years, except such advances and increased efficiency as the experience of any one year may enable the instructors in the department to reach in each succeeding year.

The regularly prescribed subjects of the fourth year may fairly be included under the preceding observation, except that the work in stiffened suspension bridges and in arch ribs has been markedly advanced, so as to keep pace with the improved methods of analysis which have recently been introduced into these branches of structural engineering. Still further advances have been arranged for the work of next year.

Thesis.— It is, and has been for many years, the aim of the Department of Civil Engineering to make thesis work a highly important part of the activity of the fourth year class, and efforts in that direction

have not been relaxed during the past year. The work of a student, throughout his course of engineering study, is almost entirely done under the guidance of instructors. Indeed, he does little, except possibly in some of his problem and design work, not largely under the inspiration and direction of the several instructors. As a result, he naturally experiences little stimulation or encouragement toward initiative effort, which is the beginning of that self-reliance which the experienced practitioner ultimately acquires. It is clearly impossible for a student to attain that degree of facility in his professional work, while undergoing his educational training, which is ultimately essential for him. It is, however, practicable at least to begin initiative self-reliant effort in his thesis. The department requires that every student shall select the subject of his graduation thesis, although he may freely confer with the instructors of the department, or with anyone else, before making a final selection. From that time he is further expected to conduct all the design, computation, or other work which may be involved in the preparation of his thesis, on his own initiative and in an entirely independent manner, without restriction, however, as to his advising with his instructors. He is also urged to seek information and advice from such practitioners as may be available for his purpose. At the same time he is made to feel that he must carefully consider and weigh the value of all data secured in this way and decide, on his own responsibility, to what extent it shall affect his thesis work. In this manner he puts himself as nearly as may be in the position of an engineer who has undertaken work for a client, for whom his thesis becomes, in all essentials, a report.

Every student is frequently cautioned to make his thesis a technical narrative, expressed in good English and written in the most creditable style at his command, so as to make it at least agreeable reading for those in whose interests it may be written.

The results have justified the importance attached to this kind of thesis work, but we find the same general difficulty as in much of our other work, i.e., there is insufficient time to enable a student to complete his graduation thesis in a thorough and deliberate way. I desire therefore to give earnest expression to the importance of relieving the second session of the fourth year from such lecture work as it may be practicable to give before that session.

Sanitary Engineering.— A material loss has been suffered in the resignation of Asst. Prof. Adolph Black, who has been rendering effective service to the University continuously for 18 years. The withdrawal of Prof. Black makes it necessary to secure an instructor who shall be a specialist in sanitary engineering, and probably to assign a part of the work heretofore done by Prof. Black to another instructor. If the course in sanitary engineering is to be effectively administered, it must receive much more material and vigorous support from the administration of the University than heretofore. We cannot hold sanitary engineering students at Columbia University unless they can secure here instruction at least equal in quality to that which can be secured elsewhere. It is earnestly hoped that this situation may be thoroughly cured

of its present defects, so that the sanitary engineering work of the department may stand second to no corresponding work elsewhere.

W. R. Peters, Jr., Research Fund.— An event of great importance to the department was the recent establishment by Mr. and Mrs. William R. Peters of a fund amounting to $50,000 as a memorial to their son, William Richmond Peters, Jr., who died as he was closing the second year of his work in this department a year ago, as a member of the class of 1912. The income of this fund is to be applied to research work in the mechanical testing laboratory and in the hydraulic laboratory. The department has never before had a specific fund available for its research work. It will now be practicable to perform a considerable amount of valuable research continuously in the two laboratories of the department. This work has already been begun and will be continued hereafter to the full extent permitted by the available income of the fund.

Highway Engineering.— The advanced course in highway engineering began on Dec. 4, 1911, and closed April 1, 1912. The session was in every way successful as educational work and 15 students were in attendance, 13 of whom are candidates for the degree of A.M. This session constituted the first year of the two years' course.

Among those who registered were three members of the Maryland State Roads Department, and one from each of the following fields of active highway work: State Highway Department of Pennsylvania; State Highway Commission of Massachusetts; The Texas Co.; the Barrett Manufacturing Co.; the American Asphaltum and Rubber Co.; the Road Contractor's office; the Civil Engineering Faculty of the University of North Carolina; and the Engineering Department of the Panama Canal; and finally three from offices of consulting engineers.

The regular lectures of the course were supplemented by lectures from 15 non-resident lecturers, including authorities in various branches of highway engineering from Chicago, Washington, Philadelphia, Boston, and New York City, the State Engineer of New York being among the number.

A large amount of apparatus for the laboratories of road material and bituminous material has been installed in the sub-basement of the Engineering Building and more has been purchased. This equipment will ultimately constitute one of the most complete road materials testing laboratories in the country, admirably adapted not only to the educational purposes for which it is designed, but also for a wide field of research.

The officers of instruction engaged in this work have kept themselves actively in touch with the more prominent highway engineering conventions and other similar projects, much to the advantage of their departmental work and to the reputation of the University as a center of this special field of educational training. It may be accepted that this part of the work of the Department of Civil Engineering has been well administered and that it has been placed upon a permanent and enduring basis, by the aid of the funds which have been and are being contributed by Mr. Charles H. Davis.

WM. H. BURR.

DEPARTMENT OF ELECTRICAL ENGINEERING.

(*Extracts from Annual Report of Head of Department for Year* 1911-12.)

A few changes have occurred in the course given by this department. The course formerly known as elements of electrical engineering, consisting of two lectures per week, is now given as Physics 5, by Prof. Wendell of the Department of Physics, and includes three lectures and two quiz periods per week. The course known as elements of the dynamo, has been increased to three hours per week for the electrical engineers by the addition of one hour for a quiz. The junior electrical engineers, in their second term, are devoting the whole of Saturday to laboratory work, which is an increase of time for this subject over that previously assigned. A portion of the course in the instrument laboratory for senior electrical engineers has been advanced to the second term of the junior year.

The senior class in electrical engineering has spent alternate Saturday afternoons in visiting electrical installations, power plants, railways, etc., and the intervening Saturday afternoons have been spent in an informal discussion of the plants visited. This is proving to be an attractive and interesting course.

During the first term of the past year the Department of Electrical Engineering gave 250 student-hours per week in lectures and 185 student-periods per week in the laboratories. In the second term the department gave 1022 student-hours in lectures and 266 student-periods in the laboratories. To do this it has been necessary to operate the laboratories three mornings a week and to have classes larger than is advisable.

Our present photometric laboratory is far from satisfactory as it is so far removed from the other electrical laboratories and thus requires the entire attention of one instructor, although only four students can work at once. It is hoped that we can move this laboratory into the same room as the instrument laboratory, where one instructor can superintend many students at once. Space has been found for this change but the money to build the light-proof enclosure, and to buy the necessary apparatus, is lacking. Some of the apparatus used in the present photometric laboratory belongs to the Department of Chemistry, which it would be necessary for the Department of Electrical Engineering to duplicate.

The Electrical Engineering Society held ten meetings during the year, under the presidency of H. R. Mellen. Among the various speakers at these meetings have been the following Columbia alumni: G. S. Dunn, '91, President of the American Institute of Electrical Engineers, "The Turin Conference"; Prof. G. F. Sever, "The Lighting of New York City"; W. W. Lighthipe, '98; "Electric Elevators"; D. Sage, '01, "Power Plant Economics"; L. J. Lewinson, '04, "Modern Incandescent Lamps," and F. J. White, '02, "Insulated Wire." H. Burgi, of the class of 1913, was elected President for 1912-13.

The demand for graduates this year is somewhat greater than it has been for several years. The men with good records in their college course have each had a choice of three or four desirable positions, while every one of the graduates was placed two days after Commencement.

In addition, the electrical manufacturing companies have given positions to several of the undergraduates for the summer.

It is my opinion that the present course in electrical engineering is too crowded. A conscientious man must work too hard to do it justice, and many of the students do not get below the surface. It is not advisable to make any important changes now, as the three-year graduate course is so soon to begin, but I think this is a condition which must be kept in view when the final details of the three-year courses are being arranged.

W. I. SLICHTER.

DEPARTMENT OF GEOLOGY.

(*Extracts from Report of Head of Department for Year* 1911-12.)

The work of the past year has been conducted efficiently and without interruption. In the microscopical study of rocks, Prof. Berkey has made some decided improvements in the elementary instruction. Funds have been provided, in addition to the regular departmental appropriation, for the purchase of sets of thin sections of typical rocks. Twenty-five slides of each kind are now in the equipment. Each student in a division of 24 has one before him under his microscope, while Dr. Berkey with the 25th slide under his microscope comments upon the important features. This plan has made the work much more systematic and uniform. Over 1000 thin sections have been obtained for the purpose.

For the fourth-year School of Mines students who have desired to take a full year's course in microscopic study, Dr. Berkey has given a special course adapted to their needs, and complete in one term. After a general review of the varieties of rocks, he has given them cases of the application of this method of study to problems in mining or other branches of engineering. Not a few of these problems have been previously attacked by Dr. Berkey and myself in actual practice and the materials have been kept for student's use. They serve to keep our work in close touch with the life of the profession outside. We have increased our equipment by three new petrographic microscopes during the year and are now very well provided with good instruments for divisions of about 25 students.

On the stratigraphic side of the department, Prof. Grabau has had good classes. Following the summer session, he went with a party of 13 on the usual trip up the Hudson Valley and west to Buffalo, stopping at the exposures of special interest. In the Easter vacation he made a three days' trip with eight students into central Pennsylvania. Again, later in the Spring, he spent three days with a party of graduate students in the Hudson Valley.

The past year has been the first in which we have carried into effect an informal plan for the exchange of junior officers with the Department of Geology of the University of Munich, a plan tentatively arranged by Professor Grabau when on his sabbatical leave in 1910-11. Our curatorship in paleontology has been most efficiently filled by Dr. F. F. Hahn, of Munich, who has brought much new information to us.

and has made important progress in putting our collections into greatly improved condition. Incidentally, Dr. Hahn himself has acquired a familiarity with American fossils and has made several valuable contributions to the literature of the subject. For the coming year he will be succeeded by Dr. Lebling, also of Munich. This informal arrangement with the University of Munich was a happy thought on the part of Prof. Grabau, and keeps us in closer touch with a famous old university, where not a few of our teaching staff in Columbia have studied in the past.

An important feature for next year has been the appointment of Douglas W. Johnson, Ph.D. in Geology in 1903, to an associate professorship in physiography. Dr. Johnson has been for six years assistant professor in this subject at Harvard. He will teach with us in the fall semester and the summer session, but will spend the spring semester in the field, taking up one large American physiographic problem after another.

In February, 1912, the undersigned was elected President of the American Institute of Mining Engineers, and in April, to membership in the American Philosophical Society. The other officers have been active in the scientific societies, local and national, in which geology is especially cultivated. Dr. Grabau was one of three specially appointed to discuss delta deposits at a symposium of the Geological Society of America in Washington, during the holidays.

J. F. KEMP.

DEPARTMENT OF MECHANICAL ENGINEERING.

(*Extracts from Annual Report of Head of Department for Year* 1911-12.)

Staff.— The most important change in the staff, to become effective next year, is due to the creation of an assistant professorship in steam engineering, the first in the history of the school, to which R. J. S Pigott, Columbia, 1906, formerly of the Interborough Rapid Transit Co., and now engineer of the New England Engineering Co., has been appointed. The vacancy created by T. M. Gunn's resignation has been filled by the appointment of G. F. Wieser, Cornell, 1910, now of the American Locomotive Co. These two changes will permit more detailed teaching in the courses on steam power plants and will make possible the elimination of all lecture work in engineering thermodynamics, as the new text-book, under preparation by the department for the past two years, will be available. For the first time, salaries have been paid to the four practicing engineer lecturers conducting the courses on elevating and conveying machinery, L. DeG. Moss, of the T. M. Robins Co.; on air machinery, F. V. D. Longacre, of the Ingersoll-Rand Co.; on shop processes, F. Halsey, Editor of *The American Machinist;* and on pumping machinery, F. F. Nickel, of the Henry R. Worthington Co. This payment for efficient service rendered makes it possible to retain them indefinitely, with a corresponding improvement in the quality of the instruction, which naturally comes from repetition.

Additional instructors are still needed in the department (a) to enable those regularly on the staff to leave the University at least two

days per week to keep in touch with engineering practice; (b) to permit a reduction of the size of the recitation sections, in the interests of better teaching and (c) to allow the assignment of each important subject to a man who has specialized in that subject. The importance of using specialists in teaching mechanical engineering subjects is probably greater than in any other branch of engineering, by reason of the very great scope covered by the profession and the important differences characterizing each branch of its practice from the rest, even though the course of instruction itself remains elementary and avoids fine distinctions. It is hoped that suitable provision will be forthcoming in succeeding years to enable this department to carry out these ideals of suitable presentation of subject matter, and thus make proper use of its natural advantages due to location in the City of New York.

Equipment.— Attention has been called in previous reports, and in budget communications, to the necessity for physical expansion of the department, if it is to take its proper place as a leading engineering school. We must have more lecture rooms and class rooms, and rooms properly adapted to their purposes. More laboratory space, with more and proper laboratory equipment, is just as sorely needed as are suitable shops. These increases in physical provision for the work of the department cannot be provided without additional buildings which might be erected on our present site or elsewhere. As it has been proposed that the University should do something to mark the fiftieth anniversary of the engineering school, it seems appropriate to consider this subject at this time.

Students' Work.— It is worthy of note that the quality of work done by the students during the past year has been better than within the memory of anyone in this department. No greater seriousness of purpose, nor better attitude toward the work can be expected, and as this department gives instruction to all the students in the schools of Mines, Engineering and Chemistry, this observation speaks well for the smooth and efficient internal working of the school as a whole.

CHARLES E. LUCKE.

DEPARTMENT OF METALLURGY.

(*Extracts from Annual Report of Head of Department for Year* 1911-12.)

Organization.— At the beginning of the academic year 1911-12, the courses in assaying were transferred from the Department of Chemistry to the Department of Metallurgy. Prof. Hall continues in charge of that work and is now, therefore, on the staff of the Department of Metallurgy. No other change was made in the organization; H. B. Allen, whom we expected to have as honorary assistant, received such a handsome offer from an outside source that it was deemed unwise to retain him in the Department. It was therefore necessary for us to obtain temporary assistance and this was accomplished by employing a former graduate for a period of three months during the second term. Provision has been made for the services of a regular assistant in this department next year.

Instruction.— Practically no changes were made in the courses given except that in a few of the advanced courses the method of instruction was modified, and some of the hours were devoted to informal conferences on metallurgical subjects. The result was eminently satisfactory.

A total of 24 courses were offered and students were registered in all of them. The number of students registered for one or more of these courses was as follows:

Special Students	2
School of Chemistry	37
School of Engineering	103
School of Mines	119
Candidates for Advanced Degrees	17
Total	278

A tabulated statement of the number of students registered in the different courses is given below:

Course	Subject	Students
101	Introduction to Metallurgy.	88
111	Metallurgy of Copper.....	87
118	Metallurgy of Copper.....	8
122	Metallurgy of Lead, Silver, Gold and Zinc	81
128	Metallurgy of Lead, Silver, Gold Zinc and the Minor Metals	6
131	Metallurgy of Iron and Steel	72
134	Metallurgy of Iron and Steel	91
138	Metallurgy of Iron and Steel	10
141	Electrometallurgy	77
148	Electrometallurgy	8
151	Constitution and Properties of Alloys	16
156	Metallography	25
158	Advanced Course on Constitution and Property of Alloys	7
62S	Summer Course in Non-ferrous Metallurgy	57
64S	Summer Course in Ferrous Metallurgy	10
66S	Summer Course in Non-ferrous Metallurgy	10
72	Metallurgical Laboratory..	58
171-2	Metallurgical Laboratory..	5
173-4	Metallurgical Laboratory..	5
175	Metallurgical Investigation.	3
177	Metallurgical Plant Construction	5
201-2	Advanced Work	1
69	Assaying	71
170	Assaying	7
	Total	808

This compares with 632 during the year 1910-11, an increase in registration of 176. The teaching staff has handled the increased work satisfactorily, but the duty imposed on each member has not been light. While the amount of research work performed was less than during some of the previous years, 17 students were registered in metallurgy for advanced degrees and have taken either their minor or major subjects in this department. Those taking their major subjects have performed their laboratory work in a satisfactory manner.

Research.— Several important pieces of research work completed in this department during previous years have been published either in the technical journals or in the SCHOOL OF MINES QUARTERLY, and these publications have received favorable comment.

The New Assay Laboratory which has now been installed on the sixth

floor of the School of Mines building was practically completed at the beginning of the past academic year, and although some difficulties were encountered in starting up the plant the results obtained have been eminently satisfactory. The plant consists of 34 individual gas-fired muffle furnaces, 8 coke-fired melting furnaces, 2 coke-fired muffle furnaces, of the western type, with a complete equipment of balances, grinding machines, storeroom, etc. Prof. Hall has found it much easier to give instruction in assaying in the present quarters, and with the modern installation, than before, and the result has proved that it is possible to give the students better service in the limited time allowed than could have been done under the former conditions. Placing the courses in assaying in the Department of Metallurgy is undoubtedly a step in the right direction, as the subject of assaying should be taught from the standpoint of metallurgical practice rather than of chemistry.

Ferrous Laboratory.— Several gas-fired furnaces for the heat treatment of steel and an independent blowing unit, to furnish blast for continued work, were installed in this laboratory, the apparatus being second-hand material taken from other departments.

Non-Ferrous Laboratory.— Owing to the increased number of students in the Department of Metallurgy, it has been necessary to increase the facilities in this laboratory, and desks with complete equipment for eight more students have been placed in this laboratory.

Museum.— During the past year we have added materially to our collection of bromide enlargements of photographs illustrating metallurgical practice, the structure of metals, etc., and these have been of great assistance in presenting the various subjects in a comprehensive manner. The old models illustrating metallurgical practice in the early days, and which are very valuable for this purpose, have been carefully gone over and properly repaired.

A. L. W.

DEPARTMENT OF MINERALOGY.

(*Extracts from Annual Report of Head of Department for Year* 1911-12.)

Staff.— Dr. M. A. Lamme resigned as Instructor, to accept the position of Director of the Institute of Geology for the Uruguayan Government. This Institute has charge of the geological study, the mining and irrigation of Uruguay, and forms part of a general scheme of industrial development recently inaugurated by that Government. Dr. Lamme's place has been taken by Harry F. Gardner, of the University of Michigan, who has been Assistant in Mineralogy in that institution, and later chemist in one of the portland cement companies in New York State.

The Trustees have made an appropriation for a "helper" in the department, in connection with the care and arrangement and replacement of the very numerous specimens used and destroyed each year in the student work. A considerably larger number of cases for storage and sorting have been acquired as rapidly as possible. It is proposed not only to maintain the working collections in better order, but greatly to

increase the variety of specimens. Graduates could greatly aid in this by sending 25 to 50 lb. of the minerals worked in their localities. It is extremely difficult to secure variety from dealers.

New Courses.— Two new courses have been established, Course H 214, for students in highway engineering, this being a course in optical mineralogy very similar to the course now given to mining engineers, and Course 10, a temporary course to be given to students in chemistry, supplementing the laboratory course in mineralogy given in the second year, and to be replaced under the new three-year schedule by Mineralogy 9-10, a somewhat longer course to be given in the fourth year.

New Publications.— Prof. Moses has printed "A Guide to Sight Recognition of 150 Minerals" which was included as part of a work by J. F. Farrell in his "Manual of Practical Field Geology." A new edition of the general textbook "Mineralogy, Crystallography and Blow-pipe Analysis," has been issued, and Prof. Luquer's "Rock-forming Minerals" will soon appear in its fourth edition.

Additions to Equipment.— The principal additions are the Koenigsberger apparatus for the study of opaque specimens, two microscopes, one petrographic and one binocular, about 100 new mineral sections, and a small electric furnace.

Comparatively few specimens have been bought for museum purposes, although a considerable amount has been spent for specimens for the student collections, especially for specimens from the West. The principal additions have been minerals from Norway and Brazil, and a few miscellaneous specimens of exceptionally good quality from dealers. There have been numerous gifts from graduates, but chiefly of material for student work, for which special requests have been made, among these being some material from British Columbia, Cuba and from Colorado, secured for the department by Mr. B. B. Lawrence.

A. J. MOSES.

DEPARTMENT OF MINING.

(*Extracts from Annual Report of Head of Department for Year* 1911-12.)

The work and personnel of this department for the past year was as stated in the official announcements. The regular work of instruction for students of the third and fourth years calls for no especial comment. A large number of additional diagrams and plates to illustrate the lectures were prepared in the photographic laboratory of the department.

A new Deister No. 3 slime table was purchased from the makers at a generous discount in price, has been installed in the ore-dressing laboratory, and was used for the work of the students in the second half-year.

During the first half-year an elaborate investigation on the operation of jigs of different types was conducted under the direction of the head of the department by T. C. Morgan, special assistant, and H. B. Taylor, a graduate student. This investigation will be continued during the coming year.

H. S. MUNROE.

BOOK REVIEWS.

A Text-book of Inorganic Chemistry. By A. SENTER. Cloth; 6×9 in.; xii + 583 pp.; illus. D. Van Nostrand Co., New York. 1911. Price $1.75

The obviously sound ideas of an author, as set forth in his preface, are often nowhere recognizable in the body of the book. In this instance, however, the promise of a book on modern lines is well performed. The book is not radical, however, but conservative. There is no originality in the choice, arrangement, or mode of presentation of the material. On the other hand, few statements which challenge criticism have been noted. The statement that, in electrolysis of sodium sulphate solution, metallic sodium is liberated, and subsequently acts upon the water, surprises us, when we remember that the author is a physical chemist. Is it not time, too, that Brodie's melting point of rhombic sulphur (114.5°) gave place to something nearer the correct value (112.8°)?

The book is well printed and of handy size.

A. S.

The Design of Mine Structures. By MILO S. KETCHUM. Cloth; 5×8 in.; 459 pp. and 250 illus. McGraw-Hill Book Co., New York. $4.

This volume explains the application of scientific methods to the solution of a class of problems which have, until recently, often been solved by rule of thumb, or by copying some other company's structures. This book is the first that has come to our notice applying the methods of graphic statics to the special types of structures employed at mines, headframes and tipples, mill buildings and coal breakers, ore bins and rock houses. It is a particularly valuable book for mining students, containing as it does a wide variety of the kind of instruction that is usually given by lectures and wall diagrams.

The first two chapters describe in a general way the structures and appliances required for hoisting. Chapter III shows the graphic method for computing stresses due to live, dead and wind loads in a simple headframe of the A-pattern, in which the stresses in all members are determinate. Chapters IV and V apply the same method to the four-post frame, in which, owing to redundant members, not all stresses are determinate; here the theory of least work has to be invoked. Chapter VI applies the knowledge of stresses gained in the preceding chapters to the actual design of a headframe, in all its parts; it then proceeds to display numerous examples, illustrated by working drawings, of headframes and rock houses in all parts of the country. It is to be regretted that in this connection only one specimen of a wooden frame is exhibited. Chapter VII gives working drawings of a number of coal tipples.

Chapters VIII and IX discuss first the stresses and then the design of steel-framed and truss-roofed buildings. Much of this is similar to the same author's earlier book on steel mill buildings. Chapter X applies the principles of the retaining-wall to the determination of stresses in bins and works out a clear solution of this difficult problem. The

selection of types of actual bin designs, however, is neither complete nor widely representative. Chapters XI and XII deal with coal washeries and breakers, and XIII with a few selected types of structures for other purposes.

Chapter XIV gives information concerning details of construction practice, dimensions and weights of steel, rivet data, etc. Chapter XV is devoted to the cost of steel, of its fabrication, erection and painting, and is a valuable fund of information not usually easy to get; this chapter will be welcomed especially by students. Appendix I contains specifications for the erection of steel buildings and mine structures, while Appendix II relates in the same way to reinforced concrete.

E. K. J.

American Mine Accounting. Methods and Forms employed by Leading Mining Companies. By W. H. CHARLTON, P.A. Cloth; 6×9 in.; 367 pp.; 250 illus. McGraw-Hill Book Co., New York. 1913. Price $5.00.

Probably no other subject of equal importance to the mining industry has been so long neglected as that of mine accounting. A few authors have touched on the subject in a more or less cursory manner in various books on mining, and numerous articles have appeared in the transactions of mining societies and in the technical press, but this volume is the first actual book of reference on the subject that has appeared in this country.

The author does not attempt to discuss methods of accounting, nor to elucidate the principles on which they are based; he merely presents the systems that are successfully employed by some of the largest operating companies in their particular fields. In each case a brief description is given of the conditions and the methods of operation, together with a statement of the number of mines embraced in the group.

The book contains six chapters, each dealing with the method of accounting for some particular branch of the mining industry, as illustrated by the method of one particular company, as follows:

Chap. I. Mining iron ore. Oliver Iron Mining Co.
Chap. II. Mining and milling native copper. Ojibway Mining Co.
Chap. III. Mining copper ore. Utah Consolidated Mining Co. Smelting copper ore. Calumet & Arizona Mining Co.
Chap. IV. Mining coal and making coke. Utah Fuel Co.
Chap. V. Mining and milling gold ore. Portland Gold Mining Co.
Chap. VI. Engineering and geological data. Calumet & Arizona Mining Co., and the Boston & Montana Con. C. and S. Mining Co.

Of the 250 figures in the book, 229 are devoted to blank forms of reports, records, cost sheets, etc., and 31 illustrate methods of recording engineering and geological data. It is to be regretted that the graphic records used by the Utah Consolidated Company are not illustrated by figures, although they are fully described and their merits emphasized in the text.

The book will be welcomed by many mine accountants. It ought to serve a useful purpose in tending to create greater uniformity in the methods of accounting at mines which are operating under similar conditions.

E. L. KURTZ.

Refractories and Furnaces. By E. T. HAVARD, E.M. Cloth; 6×9 in.; viii + 356 pp.; 124 illus. McGraw-Hill Book Co., New York. 1912. Price $4.00 net.

The author, who is associated professor of metallurgy at the University of Wisconsin, in publishing this book has supplied a much needed and up-to-date reference work on refractories, furnaces, and furnace construction. It is stated in the preface that the notes collected by the author during his activities as superintendent of furnaces and as consulting engineer formed the basis in the preparation of the book.

It is only within recent years that due attention has been given to the properties, preparation and application of materials used in the construction of furnaces. Previous to the publication of this book there was no good reference work on the subject, and such data as were of value to a furnace constructor were so scattered as not to be readily available.

The book contains descriptions of the mining and the purification of clays and other raw refractory materials, the testing and analysis of refractories, data on the manufacture of bricks and prepared refractories, and the specific uses of these in furnace construction. Data are also given on the operation of furnaces, their efficiencies, and in some cases the costs of their construction and repair. The author has made free use of the latest literature on refractories, has ably compiled the data into tables, and has presented the subjects well. Aside from several metallurgical mistakes, which are not serious, the book is well written, well printed, and contains a lot of valuable information. It is better suited as a book of reference than as a text for students.

Commendable features of the book are the special chapters on the construction of typical furnaces, the use of certain materials for specific purposes, and the physical and chemical properties of materials which are used in the construction of these furnaces. As examples may be cited: Chap. VI, which is devoted to refractories used in the metallurgy of iron and steel; Chap. VII, to those used in the metallurgy of copper; and Chaps. VIII and IX, to those used in the metallurgy of lead, silver, and electro-metallurgical industries.

The book should be well received by metallurgists, and should prove a helpful addition to the library of anyone who either constructs or works with furnaces. A timely protest which may be offered, with reference not merely to this book but to other recent books, is against the high price charged by the publisher.

E. F. KERN.

UNIVERSITY NOTES.

Admission of Students with Advanced Standing.— The requirement of at least three years of general college or scientific school education for admission to the graduate course in the Schools of Mines, Engineering and Chemistry, which will become compulsory in September, 19 4, lends special interest to the fact that the number of students admitted to these schools with advanced standing for the current academic year has increased 40 percent. over the number admitted last year.

In 1911-12, 60 students were admitted with advanced standing, of whom 25 held first degrees. This year 84 students have been admitted with advanced standing, 34 of whom had already received a first degree. These students come from 31 institutions in this country and from 10 foreign institutions, representing eight foreign countries, as follows:

Name of Institution	*Students*
Amherst	1
Baltimore Polytechnic	1
Brooklyn Polytechnic	2
Colgate	1
College City of New York	12
College of Pharmacy	3
Columbia College	22
Cooper Union	2
Dartmouth	2
De La Salle	2
Harvard	1
Lovola	1
Mass. Inst. Technology	1
New York University	3
Princeton	1
Purdue	2
Randolph-Macon	1

Name of Institution	*Students*
St. Francis Xavier	1
Union	1
University of Arizona	1
" " California	1
" " Illinois	1
" " Utah	1
" " Virginia	1
" " Washington	1
Ursinus	1
Wesleyan (Connecticut)	1
Western Reserve	1
Whitman	2
Williams	2
Yale	1
	74

Name of Foreign Institutions	*Students*	
Hunan Technology, Hunan, China	1	
Mackenzie College, Brazil	1	
Imperial Royal College, Brzojaued, Austria	1	
Russian Gymnasium (not named)	1	
St. Stephens College, Hong Kong, China	1	
School of Arts & Trades, Havana, Cuba	1	
Thal Gymnasium, Thuringia	1	
College of France, Paris, France	1	
University of Toronto, Toronto, Canada	1	
Yale College, Chang Sha, Hunan, China	1	10
	Total	84

Department of Mining.— The Senior class in mining has lately had the advantage of a number of unscheduled lectures by engineers engaged in active work. In November, James M. Hyde, formerly Professor of Mining at the University of Oregon, gave a lecture, illustrated by laboratory experiments, on the subject of flotation processes. Mr. Hyde was the inventor of the process installed and now in successful operation at the Butte & Superior mine, at Butte, Mont. During the few weeks previous to his lecture, he was engaged in research in our ore-dressing laboratory.

On Dec. 3, H. L. Mead, E.M., 1905, delivered a lecture on the principles involved in the examination, development, and operation of hydraulic gold mines. His illustrations, of which he used a large assortment, belonging to the Department of Mining, were drawn from the operations of La Grange mine, in California, with which he had been associated for several years.

On Dec. 2, James R. Finlay, author of "The Cost of Mining," addressed the class on "The Elements of Mine Valuation." A verbatim report of this lecture will be found on preceding pages of this issue. Later in December, Mr. Finlay delivered two lectures on "The Basic Factors of Mining Costs," indicating the manner in which the cost of conducting a given mining enterprise is influenced by (a) external factors; (b) internal factors; (c) management. In the two hours, Mr. Finlay did not quite complete his remarks; we hope to present a full report of them in forthcoming issues.

E. K. J.

Course in Highway Engineering.—The following non-resident lectuers in highway engineering at Columbia University have been appointed for the 1912-13 session: John A. Bensel, New York State Engineer; William H. Connell, Chief, Bureau of Highways and Street Cleaning, Philadelphia; Morris L. Cooke, Director, Department of Public Works, Philadelphia; C. A. Crane, Secretary, The General Contractors Association; W. W. Crosby, Chief Engineer to the Maryland Geological Survey and consulting engineer, Baltimore; Charles Henry Davis, President, National Highways Association; A. W. Dow, chemical and consulting paving engineer, New York City; Walter H. Fulweiler, Engineer, research department, United Gas Improvement Co.; John M. Goodell, Editor-in-Chief, *The Engineering Record;* D. L. Hough, President, The United Engineering and Contracting Co.; Arthur N. Johnson, State Highway Engineer of Illinois; Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City; J. C. Nagle, Professor of Civil Engineering and Dean of the School of Engineering, Agricultural and Mechanical College of Texas; Harold Parker, First Vice-President, Hassam Paving Co.; H. B. Pullar, Assistant Manager and Chief Chemist, American Asphaltum and Rubber Co.; J. M. F. de Pulligny, Ingénieur en Chef des Ponts et Chaussées, et Directeur, Mission Francaise d'Ingénieurs aux Etats-Unis; John R. Rablin, Chief Engineer, Massachusetts Metropolitan Park Commission; Clifford Richardson, consulting engineer, New York City; Philip P. Sharples, Chief Chemist, Barrett Manufacturing Co.; Francis P. Smith, chemical and consulting paving engineer, New York City; Albert Sommer, consulting chemist, Philadelphia; George W. Tillson, consulting engineer to the President of the Borough of Brooklyn.

In connection with the course in highway engineering, the following illustrated lectures, open to the public, have recently been given: Dec. 13—"Concrete Highway Bridges," by Arthur N. Johnson. Dec. 20—"Mining of Gilsonite and Manufacture of Gilsonite Products," by H. B. Pullar. Dec. 27—"Manufacture of Refined Water Gas Tar," by Walter H. Fulweiler. Dec. 30—"Manufacture of Refined Coal Tar,"

by Philip P. Sharples. Jan. 21 —" Maintenance of Sheet Asphalt Pavements," by Francis P. Smith.

A. H. B.

Sigma Xi.— On Nov. 21 Prof. C. A. E. Winslow, of the College of the City of New York, delivered a lecture before the Columbia Chapter of Sigma Xi on " Some Aspects of the Public Health Campaign." This lecture was well attended by members and their friends.

On Jan. 16, 1913, Prof. Henry C. Sherman of the University, lectured on " Progress and Problems in Food Chemistry."

The annual meeting of the Chapter for the election of officers and of new members, and for the transaction of other business, will be held at the University on March 12, 1913. The initiation ceremonies and dinner will take place on April 10.

Members of the Columbia Chapter of Phi Beta Kappa will be guests of Sigma XI on May 8, when Prof. Cassius J. Keyser, of the College, will deliver an address on " The Scientific Role of Continuity: Sensible and Conceptual Continua."

Tau Beta Pi.— The honorary engineering society on Nov. 11, 1912, elected the following from the class of 1913: E. H. Findlay and Elmer Roberts, civil engineers; H. Burgi, Jr. and P. Hamilton, electrical engineers; L. W. Hickey and R. Lunn, mining engineers; E. W. Stone, mechanical engineer.

Phi Lambda Upsilon.— This honorary chemical society had a very successful year. Several new chapters were added and the membership has been rapidly increasing. A large number of the best known chemists and chemical engineers are now members of this society. It has been the purpose of the Columbia chapter to hold open meetings from time to time, at which papers are read on technical subjects of interest to both chemists and engineers.

At the Fall open meeting, held Nov. 7, 1912, a very pleasing departure was made from the rule of presenting only papers of a technical nature. Marcus Benjamin, Ph.D., of the National Museum, Washington, a Columbia alumnus, who has kept in touch with Columbia graduates for many years, delivered a very enjoyable address entitled, " Some Columbia Chemists." Consisting, as it did, of personal reminiscences and anecdotes of their experiences and attainments, it was greatly enjoyed by all present.

Early in the Spring another open meeting will be held. At this time a prominent speaker will be secured to talk on something of interest to the members of the society. Suitable notice will be given and it is hoped that many friends here in the University will also avail themselves of the opportunity thus afforded.

M. M. DURKEE, *Secretary.*

Senior Mining Society.— At a meeting on Nov. 20, 1912, the following amendments to Article 3 of the constitution were adopted: " Sec. 4.— The active membership of the Society shall not be limited." " Sec. 6.— All members of the Senior class of the School of Mines, or members taking the majority of their work with the Senior class, shall be

eligible to membership in the Society." It is believed that this action will alleviate a certain feeling of dissatisfaction among members of the Senior class not heretofore elected to the limited membership of the Society.

At the meeting of the Society on Nov. 9, H. G. Davis, of the D. L. & .W Company's coal mining department gave an illustrated lecture on methods of decreasing the dangers of coal mining, with special reference to the efforts put forth by his company to educate its illiterate European miners. The copious illustrations of the lecture prevent its reproduction in the QUARTERLY. At the same meeting, W. P. Jennings, mine inspector for the Pennsylvania Coal Co., at Pittston, Pa., gave an extemporaneous talk on the application of electricity to anthracite mining, with special reference to a recently devised undercutting machine. This address will be found in full on a preceding page of this issue.

At the meeting on Dec. 4, Dr. R. W. Raymond discussed the status of mining engineering in Japan, with notes drawn from the recent visit of the American Institute of Mining Engineers to that country.

E. K. J.

Civil Engineering Society.— The first meeting of the year was held in Room 301 University Hall on the evening of Tuesday, Nov. 26. W. F. Thoman, C.E., '06, of the Webber Construction Co., gave a very interesting talk on the Rye outlet bridge. This is a five-span, reinforced-concrete, highway bridge and was built by the Board of Water Supply of New York City to carry a highway over a section flooded by the water impounded by the Kensico dam.

Mr. Thoman spoke from the contractor's viewpoint, showing some of the problems encountered in falsework and centering, and then took up the method of making an estimate on such work. The talk was illustrated by sketches on the board and by means of photographs, drawings and blue prints, making the subject clear, interesting, and instructive.

The attendance was 25, and after the lecture refreshments were served by the Commons. Several alumni members were present and it is requested that any other members who did not receive notification of the meeting, and who desire to be notified of subsequent meetings send their names and addresses to E. H. Findlay, Secretary, 175 West 73d Street, New York.

J. K. F.

Mechanical Engineering Society.— At a meeting of the Columbia University Student Branch of the A.S.M.E., on Oct. 30, reports on power plant experience were read by L. Grossbaum and Howard Swallow. Practical work in the shops and drafting rooms of representative manufacturing establishments was described by J. A. Stewart and Mr. Sengstaken.

Mr. Place, of Warren & Whetmore, Architects, delivered a lecture on "The New Grand Central Terminal." He discussed at length the special features of construction from the mechanical engineer's standpoint, emphasizing the extraordinary means used to insure complete comfort

and safety to the thousands of persons housed in the terminal or passing through it daily. Special mention was made of the duplication of all apparatus subject to hard or important service, in order to reduce to a minimum any possible interruption in train operation or house service.

At the meeting of Jan. 10, the topics "Gas Engine Design" and "Furnaces and their Construction," were discussed. W. F. Rittman recounted his experiences with various types of furnaces, mentioning the new theories regarding explosive mixtures and combustion. M. H. C. Brombasher related numerous incidents which have occurred in the designing and marketing of the modern gas engine. After the meeting the society adjourned to the Commons, where refreshments were served.

E. W. STONE, *President.*

Geological Journal Club.— At the meeting of Dec. 5, F. F. Hintze gave an interesting account of the Palaeozoic section in the Wasatch Mountains, southeast of Salt Lake City, of which he made a careful study during the past summer. He finds that the section made by the Fortieth Parallel Survey, which has been accepted as the standard, needs considerable revision. Warren Smith reviewed C. Godfrey Gunther's book, "The Examination of Prospects." This book, written by a Columbia mining engineer, 1903, treats of those phases of geology which have a direct bearing on ore deposits, and being of convenient size to carry into the field, is primarily intended as a guide for engineers who are called upon to examine an ore-deposit. Y. T. Wang gave a humorous account of a trip taken by him and two other graduate students to the Catskill Mountains during the Thanksgiving vacation.

C. R. F.

Geology of Panama.— Under the auspices of the Department of Geology, Donald F. MacDonald, geologist for the Panama Canal Commission, delivered a lecture, Jan. 17, on "The General Geology of the Panama Canal Zone." He described in considerable detail the nature of the rocks in the vicinity of the Culebra cut and pointed out how the trouble that has been experienced from slides is due to the peculiar conditions under which the rocks occur. Quick growing vegetation has been planted in an effort to restrain these slides. Mr. MacDonald thinks it very unlikely that the canal will ever be disturbed by earthquakes, because no severe shocks have been recorded within the history of the Isthmus, nor is the rock formation such as to give rise to earthquakes. The lecture was well illustrated by lantern slides, and was thoroughly enjoyed by a large audience.

Metallurgical Lectures at Annapolis.— The department of metallurgy has been honored with an invitation to conduct a series of lectures on the metallurgy of iron and steel at the U. S. Naval Academy, at Annapolis, Md. Professor Walker will outline the course in the first lectures, and will be followed by Professor Campbell, who will cover the ground in greater detail.

Gift to School of Mines.— The School of Mines is deeply grateful to J. Parke Channing, E.M., 1883, for the gift of $12,500 to pay for ad-

ditions to the equipment of the metallurgical laboratories and for reconstruction of some of the interior arrangements of the School of Mines building. The more important changes, which have been under consideration for more than a year but have heretofore lacked the necessary funds, are the following: The present non-ferrous laboratory will be moved from the south end of the second floor to the north end of the top floor, and will be enlarged by the addition of special equipment devoted to electro-metallurgy. The large room on the second floor, thus vacated, will be furnished as a library and reading room, into which will be moved all the reference books now separately maintained by the departments of mining and metallurgy, as well as the large collection of books on these subjects now reposing in the main library. The joint library will be cared for by a special librarian. The two small rooms on the second floor, now occupied as libraries, will be altered, one into a lecture room, and the other into a locker and lounging room for students. The work of carrying out these plans will be performed during the next summer.

Honor System.—As in the two preceding years, the mid-year examinations of the Senior class in January were conducted by the students on the honor system. The system was organized by a committee of seven members of the Senior class, appointed and headed by the president of the class, and a formal constitution was drawn up defining and regulating the various practical details, along lines very similar to those in force at Princeton, Williams, and other colleges. As yet, the system has been adopted only by the Senior class in the engineering schools, except that the students of civil engineering have not given their assent to the plan. In the three years it has now been in operation, the results have been eminently satisfactory, from the standpoint of students and faculty alike, and the hope is expressed that the system will eventually be extended to cover examinations in all classes and in every department.

FACULTY NOTES.

The second, revised and enlarged edition of Professor Smith's "Einführung in die allgemeine und anorganische Chemie" appeared in November, 1912. A year ago, the College Entrance Examination Board asked Professor Smith to serve as chairman of a commission to revise the entrance requirements in chemistry. This commission presented its report in the autumn of 1912, and it has been accepted. Professor Smith addressed the Chemistry Club of Princeton University on Dec. 10, and the advanced students in Wesleyan University on Dec. 18, 1912.

Professor S. A. Tucker has been appointed a delegate of the American Electrochemical Society on the Perkin Medal Committee. Among the papers recently published by those in the Department of Chemistry are the following: S. A. Tucker and Y. T. Wang; "The Action of Nitrogen on Strontium Carbide," VIII Inter. Cong. App. Chem., Vol. XXI, pp. 121-126. S. A. Tucker and Henry L. Read: "Fixation of Nitrogen by Alumina and Carbon," *Met. and Chem. Eng.*, X, pp. 745-746.

Professor M. T. Bogert recently delivered addresses as follows: Nov. 15.— City Club, Boston, Mass., before joint meeting of New England Sections of the Society of Chemical Industry and the American Chemical Society. His subject was, "A plea for closer coöperation between manufacturers and the universities and technical schools." Dec. 16. — McGill University, Montreal, Canada, before the McGill Chemical Society. Topic, "The Classification of Carbon Compounds." On the same date, at Cooper's Limited, Montreal, Canada, before the Canadian Section of the Society of Chemical Industry. Topic, "The Education of the Chemist." Dec. 17.— The Engineers' Club, Toronto, Canada, before chemists and engineers. Topic, "Coöperation between manufacturer and university."

In an interview published in the *New York Times* on Dec. 1, Professor Charles F. Chandler, President of the New York Tenement Economics Society, announced that he is holding frequent conferences with a view to securing an amendment of the present tenement house law, so as to permit sanitary housing of the poor in model tenements at moderate rents.

Professor J. F. Kemp was elected First Vice-President of the Geological Society of America, at its annual meeting at New Haven, Conn., Dec. 28-31, 1912. He also acted as toastmaster at the annual dinner on this occasion, addressing the guests in his well known humorous vein. Professor Kemp has accepted the following invitations to lecture during the Winter: Three lectures to the students in mining engineering at McGill University, Montreal; one to the Mining Society at Yale; and one to the students of the School of Mines at Pennsylvania State College. At the close of the session of the American Institute of Mining Engineers, in Cleveland, Nov. 1, at which he presided as President, he addressed the entire student body of the Case Scientific School, on "The Geological Problems in the New Catskill Aqueduct."

The Council of the Institute of Civil Engineers has awarded a Watt Gold Medal to Professor William H. Burr for a paper read at its 1911-12 session.

Arthur H. Blanchard, Professor of Highway Engineering in Columbia University, on Nov. 25, 1912, delivered an address entitled, "The Art and Science of Highway Engineering," at the celebration of Founder's Day at the Clarkson School of Technology.

R. J. S. Pigott, Associate Professor in the Department of Mechanical Engineering, has recently been appointed Assistant Mechanical Engineer to the Interborough Rapid Transit Co., of New York. He was also recently elected junior member of the A.S.M.E.

Douglas W. Johnson, Ph.D., Associate Professor in the Department of Geology, is the author of a paper on the "Fixité de la Côte Atlantique de l'Amerique du Nord," published in the *Annales de Géographie,* May 15, 1912.

Prof. Walter Rautenstrauch, of the Department of Mechanical Engineering, published a paper on "Teaching the Principles of Scientific Management," in the *Bulletin* of the Society for the Promotion of Engineering Education, November, 1912.

On Jan. 16, Professor W. Campbell delivered a lecture before the Philadelphia Section of the American Chemical Society, on "Metallography and Its Application to the Work of the Analytical and Consulting Chemist." This lecture was illustrated and was thoroughly appreciated by an audience of about 100 members and their friends. Prof. Campbell will read a paper on "Monel Metal," at the next meeting of the Canadian Mining Institute, at Ottawa, Mar. 5, 1913.

ALUMNI NOTES.

By oversight at the bindery, the loose sheet of blue paper intended for the convenience of alumni in reporting personal notes, was omitted from the majority of the last issue. It will be found on advertising page 10 of this issue, and the editors sincerely hope that the alumni will put it to its intended use.

1881. Walter G. Eliot, E.M., C.E., Ph.D., is Commissioner of Parks for the Borough of Queens, New York City.

1882. Charles B. Going, Ph.B., Chem., Managing Editor of *The Engineering Magazine,* New York, was married, Dec. 18, 1912, to Mrs. Marie Overton-Corbin, at Hartford, Conn.

1887. George S. Rice, E.M., is the author of Miners' Circular No. 9 —"Accidents from falls of roof and coal"—recently issued by the U. S. Bureau of Mines.

1887. The regular annual reunion of '87, School of Mines, was held on the evening of Dec. 10, 1912, the class being on this occasion the guests of William Jay Schieffelin, at his residence at 5 East 66th Street, New York. Dr. Schieffelin is a very loyal member of the class organization and has had the annual dinner at his home on two previous occasions. Those in attendance were: Agramonte, Bellinger, A. L. Burns, Church, Congdon, Donnell, Ferguson, Gage, Goldsmith, Heinsheimer, Huntting, Jacobs, J. Lahey, Luquer, Lusk, MacKaye, Middleton, Nichols, O'Connor, Rice, Schieffelin, Smith, Stevens, Tiemann, and Trask. The business transacted included the election of new officers to serve three years, as follows: President, G. F. D. Trask; Vice-president, E. D. Church; Secretary-treasurer, H. S. MacKaye; and Historian, B. B. Goldsmith. A number of interesting communications were read from absent members, some of them far from New York. The next meeting of the Class is scheduled for December 9, 1913.

1889. Commander Russell Raynor, Ph.B., of the New York State Naval Militia was a delegate to the annual convention of the National Guard Association of the United States, recently held at Norfolk, Va.

1892. Samuel Friedman, C.E., is one of the Commissioners of the City of Tuscaloosa, Alabama.

1892. Heinrich Ries, Ph.D., Professor of Geology at Cornell University, will read a paper on "The Clay Resources of Western Canada," at the next meeting of the Canadian Mining Institute, at Ottawa Mar. 5, 1913.

1893. H. K. Masters, E.M., is now at Marion, Ky., with the Ohio Fluorspar Co.

1895. Louis D. Huntoon, E.M., is secretary-treasurer of the New York section of the American Institute of Mining Engineers and of the New York section of the Mining and Metallurgical Society.

1895. Morril B. Spaulding, E.M., is now manager of the Pittsburg

district for the Crocker-Wheeler Co., with offices in the Oliver Bldg., Pittsburg, Pa.

1895. B. P. Carter, E.M., for the past ten years General Manager of the Ferreira gold mine, was recently transferred to a similar position with the Robinson Gold Mining Co., Johannesburg, South Africa.

1896. Harrison K. Bird, E.E., who served as military secretary to Governor Benjamin B. Odell some years ago, has been nominated by Brigadier General George R. Dyer, of the State Militia, as ordnance officer of his staff, with the rank of Major. During the war with Spain, Major Bird was Second Lieutenant of Company D, 171st New York Infantry, later going to the 71st Regiment.

1898. William A. Bostwick is Vice-President of the Orford Copper Co., 43 Exchange Place, New York.

1898. H. B. Machen, C. E., 202 Riverside Drive, New York, is chairman of the Committee on High Pressure Fire Service Systems of the National Fire Protection Association.

1900. Elbert S. Barlow, E.E., is Vice-President and Treasurer of the Hedden Construction Co., 1 Madison Avenue, New York.

1900. James F. McClelland, E.M., Professor of Mining at Sheffield Scientific School, was married, Dec. 7, 1912, to Jane Adams Kearny, at New Haven, Conn.

1901. David M. Myers, Mech. E., consulting engineer at 17 Battery Place, New York, has recently been elected full member of the A.S.M.E.

1902. Howard R. Stewart, E.M., formerly of Detroit, Mich., is now addressed at 5 Rodway Road, Roehampton, London, S.W., England.

1903. A daughter, Grace Ellen, was born on Oct. 8, 1912, to Mr. and Mrs. Silas Frederick Shaw, E.M., at San Antonio, Texas.

1903. College and Science held an informal dinner at the Aldine Club, New York, on the evening of Dec. 13. Forty-two men were present. Interest centered naturally around the plans for the approaching Decennial. It was voted unanimously to hold another dinner on Tuesday, March 25, 1913. The treasurers reported decennial funds arriving all the time but urged all possible despatch in forwarding contributions. Among the engineers present were Crocker, Cornell, Evans, Hull, Weekes, Cutter, Bigelow, Bradley, Murphy.

1904. Sheldon Smillie, E.M., manager of the Vintondale colliery, Vintondale, Pa., visited New York in December.

1905. Bleeker L. Wheeler, E.M., mineral examiner in the U. S. Forest Service, recently returned to his headquarters at Ogden, Utah, after a month's trip to southeastern Alaska.

1905. H. L. Mead, E.M., left New York, Dec. 12, 1912, in company with A. H. Rogers, to report on a mining property in Guanajuato, Mex.

1906. Harold Baxter, E.M., who was for some time Vice-President and General Manager of the Cunningham Pass Copper Mining Co., Wen-

den, Arizona, has returned to Columbia for a law course. He will specialize in mining and irrigation law.

1906. Carl E. Lloyd, E.M., recently returned from Mexico, sailed about Dec. 15, 1912, for Chile, where he is to be engineer for the Central Chile Copper Co.

1906. Robert S. Schultz, Jr., E.M., for some years engineer for the Victoria Copper Mining Co., Victoria, Mich., resigned his position in September, 1912, to become the superintendent of mining operations of the Atlas Portland Cement Co., Hannibal, Mo.

1906. Clarence M. Haight, E.M., formerly engineer of the Michigan Copper Mining Co., Rockland Mich., and for the past two years engineer with the Oliver Iron Mining Co., Hibbing, Minn., on Jan. 1, 1913, entered the employ of the New Jersey Zinc Co., at their Franklin mines, in the capacity of assistant mine captain.

1906. L. O. Kellogg, E.M., has, since graduation, spent three years as engineer and assistant superintendent with the American-Rincon Mining Co., Temoscaltepec, Mex.; one year as superintendent with the Germany Mining and Development Co., Kelly, N. M., and one year with the Sierra Mining Co., Ocampo, Chih., Mex., as engineer. He has now taken a position on the editorial staff of the *Engineering and Mining Journal,* New York. Address: 612 W. 137th Street.

1907. Mowry Bates is manager of the Hughes Porcupine Mines, Ltd., Porcupine, Ontario.

1907. On Nov. 15, 1912, a daughter was born to Mr. and Mrs. Frederick Kruse, Jr., E.M., 214 Parkside Avenue, Brooklyn.

1907. Z. P. Halpin, E.E., was married recently to Miss Virginia Mercer, daughter of Mr. and Mrs. George Mercer, 53 West 72d. Street, New York.

1907. D. P. Babcock, C.E., is first assistant engineer in the State Highway Department, Albany, N. Y.

1907. George E. Farish, E.M., was married Nov. 28, 1912, to Miss Ellen Douglas, of St. Joseph, Mo. His address is: Motherlode Mine, Salmo, B. C.

1908. H. F. Davis, E.M., is now in St. Louis. Address, care Charles B. Davis, 610 Wainwright Building, 7th and Chestnut Sts., St. Louis, Mo.

1909. Charles O'C. Sloane, Mech. E., and Miss Adelaide Jenkins Kernan were married in Saint John's Church, Utica, N. Y., Nov. 25, 1912.

1909. Edward J. Hinkel, E.E., formerly in the employment of the Queens Light and Power Co., Long Island City, is now connected with the Rider Avenue Station of the New York Edison Company.

1909. John Baragwanath, who, while in Columbia College, took many courses in the School of Mines, is now in charge of the San Miguel mine, at Morococha, Peru.

1909. J. J. Wolfersperger, E.M., is planning to leave Mexico, where he went after leaving the Cornucopia Mines Co., at Cornucopia. Ore. During the last 18 months he has been with the Cia. de Real del Monte y Pachuca. at Pachuca, Hidalgo, and more lately with the Fresnillo Co., at Fresnillo, Zacatecas. His permanent address is 708 W. Third Street, Sterling, Ill.

1910. Horace T. Herrick, Chem. E., has a position in the research laboratories of the New Jersey Zinc Co., at Palmerton, N. J.

1910. R. E. Walters, E.M., is manager of the Snowstorm mine, Wallace, Idaho; at the same mine, G. W. Roddewig, '09, is engineer, and M. W. Heller, '12, is mill foreman.

1910. T. R. Wilson left New York about Dec. 1, for geological work in connection with explorations for oil in Venezuela. Address, care of New York & Bermudez Co., Port of Spain, Trinidad, W. I.

1910. A. A. Heimrod, M.A., has resigned his position with the Balbach Smelting and Refining Co., at Newark, N. J., and is now visiting his people in Berne, Switzerland.

1910. Joel D. Marder, C.E., has been appointed inspector of iron and steel in the Bureau of Buildings, Manhattan Borough, New York, under Rudolph P. Miller, C.E., 1888, who is Superintendent of Buildings.

1910. A. B. Menefee, E.M., is with the Empire Steel and Iron Co., Wharton, N.J., as superintendent of mines in charge of the Mount Hope mine at Wharton, and of the Washington mine at Oxford, N. J. He is planning to leave the East and go to Arizona.

1911. A. R. Parker, Mech. E., is employed in the shop management department of the T. R. Almand Manufacturing, Co., Ashburnham Mass.

1911. Samuel Melitzer, E.M., spent the Christmas holidays in New York. He has charge of one of the main levels of the Ray Consolidated Copper Co., at Ray, Ariz. Preston E. Locke, '09, and M. Helmrich, '08, are also employed at Ray.

1911. Albert L. Baum, Mech. E., is with Nyrgen, Tenney & Ohlmes, consulting engineers, 87 Nassau Street, New York.

1911. Clinton Brettell, Mech. E., of Bridgeport, Conn., is on the staff of the Locomobile Company of America; his duties are to supply engineering data and solve traction problems for the different branches of the company.

1911. Walter M. Stephen, E.M., is with the U. S. Forest Service, at Portland, Ore. He spent the latter half of 1911 in the Bering River coal fields, Alaska, and during 1912 examined mining claims on the Government forest reserves in Oregon and Washington.

1911. E. Latimer, who is engaged in mill work at Garfield, Utah, visited New York in January, 1913.

1911. Percy R. Iseman, E.M., with the Yukon Gold Mining Co., at

Dawson, Y. T., is now temporarily engaged in the investigation of mining properties in Colombia, South America.

1911. E. C. Dwyer, E.M., engineer with the Federal Mining and Smelting Co., Wallace, Idaho, spent the Christmas holidays in New York.

1911. J. W. Koster, E.M., is in the explosives testing laboratory of the U. S. Bureau of Mines, at Pittsburgh, Pa. He visited New York in December, 1912.

1912. K. H. Donaldson, E.M., is in charge of special testing work at the B. & M. plant, at Great Falls, Mont.

1912. E. Marquardt, J. E. Bell, J. M. Lovejoy, and R. T. Hirsch, '11, at last accounts, were with the Chile Exploration Co., at Chiquicamata, via Antofagasta, Chile. M. M. Thompson, '09, R. A. McGovern, '10, and W. A. Scheuch, '12, recently returned from there.

1912. M. W. Heller, E.M., millman with the Snowstorm Copper Mining Co., near Mullan, Idaho, visited New York in January, 1913.

1912. R. M. Ruthardt is surveyor and geologist with La Fe Mining Co., at Guadalupe, Zacatecas, Mex.

1912. Charles M. Warner, Met. E., is at the Midvale lead smelting plant of the U. S. Smelting Co. He was first engaged in construction work, was then put in charge of the Dwight-Lloyd roasting division, and is now occupied, under the chief engineer, with experimental briquetting of coal dust for the coal companies affiliated with the U. S. Coal Company.

Alfred E. Carter, C.E., 1904, died in New York, June 11, 1912. Before attending Columbia, Mr. Carter graduated as B.S. from the University of Nebraska. In his Senior year at Columbia, he was elected to the honorary scientific society Sigma Xi. From the time of his graduation until his death he was connected with the Rapid Transit Subway Construction Co., in the position of resident engineer.

ESTABLISHED 1851

EIMER & AMEND

205-211 Third Ave.,
New York City

HEADQUARTERS FOR

Chemicals, Chemical Apparatus and Assay Supplies

Mine Laboratory Supplies

Platinum Ware—best hammered.

Pyrometers, Optical, Thermo-Electric

Electric Furnaces for Laboratory Purposes

Balances and Weights of every Description

Chemicals, Chemically pure and Technical

COMPLETE LABORATORY
AND
PROSPECTING EQUIPMENT

First Quality Supplies Only

Prompt Service

POWER TRANSFORMERS

There is no other type of transformer on the market to-day in which strength, high efficiency and good regulation of voltage are combined so successfully as in the Crocker-Wheeler core type, butt joint transformer. Time and again comparisons have been made between it and transformers of other makes, and the Crocker-Wheeler apparatus proved superior in every case. Large numbers of these transformers, now installed in all parts of the country, are proving this daily by their faultless operation.

Write for our bulletin 154.

LIGHTING TRANSFORMERS

Everything you want in a lighting transformer is found in our REMEK type. They have durable and strong insulation, low core loss, high all day efficiency, good regulation for lighting, good regulation for motor loads even with low power factor, low and uniform heating, low exciting current, durability and ample capacity for overloads, simplest mechanical construction, facility of repair, and light weight.

Write for our bulletin 151.

CROCKER-WHEELER CO.

Ampere, N. J., Baltimore, Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, Indianapolis, Los Angeles, Milwaukee, Newark, New Haven, New York, Philadelphia, Pittsburg, Salt Lake City, San Francisco, Springfield, Syracuse, Washington, D. C.

Per 27

Vol. XXXIV. No. 3. APRIL, 1913

THE

SCHOOL OF MINES QUARTERLY.

A JOURNAL OF APPLIED SCIENCE.

CONTENTS

PRINCIPLES OF HYDRAULIC MINING. By *H. L. Mead*..... 187
HYPERBOLIC FUNCTIONS AND THEIR APPLICATION TO PROBLEMS IN ELECTRICAL ENGINEERING. By *J. H. Morecroft*..... 202
REINFORCED CONCRETE STUDIES. I.—HOLLOW DAM OF THE BUTTRESS TYPE. By *J. K. Finch* and *W. F. Thoman*.... 219
ECONOMICS OF MOTOR TRUCKING—I. By *Clinton Brettell*... 241
TESTS OF FIREPROOF CONSTRUCTION FOR THE CITY OF NEW YORK. By *Harold Perrine* 259
MOSESITE. By *F. A. Canfield* 276
BOOK REVIEWS 278
UNIVERSITY NOTES 285
FACULTY NOTES 291
ALUMNI NOTES 292

COLUMBIA UNIVERSITY
NEW YORK CITY

Registered at the New York Post Office as Second Class Matter

TWO DOLLARS PER YEAR. FIFTY CENTS PER NUMBER.

All Remittances should be made payable to order of "The School of Mines' Quarterly

"DENIED"

In connection with our Suit against

The Tonopah-Belmont Development Co.

(Defended by the Butters Filter Co.)

for infringement of the MOORE PROCESS PATENT on a motion made by the defendants for a rehearing of the case, alleging that errors of fact existed on which the previous decision rested, the United States Circuit Court of Appeals for the Third District has issued its decision "denying" the motion for a rehearing. This decision confirms the sweeping judgment recently handed down in favor of The Moore Process Patent.

Verbum Sap.

The Moore Filter Company

New York, U. S. A.

THE
SCHOOL OF MINES
QUARTERLY

VOL. XXXIV. APRIL, 1913. No. 3.

PRINCIPLES OF HYDRAULIC MINING.*

BY H. L. MEAD.†

Let us first outline the different types of gravel deposits. In general, all such deposits are formed by the wearing down of gold-quartz veins, first by oxidation and then by erosion and collection in stream beds. There are three classes:

1. Present river channels, such as the Sacramento River, in California, and the benches above the river.

2. Ancient river channels, as found throughout California and the Western States. Some of them are quite intact — almost in the same condition they were in when the change in topography altered the drainage system. Some remain only in small fragments. The La Grange is one of these, of which only 1½ miles remain. The ancient river channels, in a number of cases, are covered with more or less barren material, in the form of clay or gravel, sometimes due to the fact that the ancient rivers' grade was becoming more and more flat, so that the heavier gravels were near the bottom. Some of the ancient channels are covered to an extent of two or three hundred feet with barren material. Some of them are covered by glacial drift; in other cases, the channels have been covered by volcanic flows. This gives rise to several interesting types; near Oroville, California, an old stream has been covered by a volcanic flow, which is very hard and has resisted the erosion more strongly than the surrounding country rock, so that we now find

* Special lecture in the Department of Mining, Dec. 3, 1912.
† E. M., Columbia, 1905. Lately engineer with La Grange Mining Co., California.

under Table Mountain an old river channel. The present system of drainage is superimposed on the old topography.

3. Beach deposits, of which that at Nome, Alaska, is an excellent example. These may be derived by a sinking coast, or by the submergence of river gravels. Subsequent concentration by waves and coastal currents has worn away a large portion of the gravel, leaving the remainder with a gold contents high enough to be worked profitably. Beach deposits may also be derived by the breaking down, by waves, of gold-bearing rocks forming the coast, but in most cases they are to be traced to the working over of alluvial gravels — river channel deposits at the margin of the sea.

The particles of gold in most gravel deposits are fine; it is very seldom that large nuggets are found. That is, the gold occurs in about the same state that it would be found in mineral veins, and we know how rare it is to find masses of gold, even in the richest of our veins, which are of any important size, that is, 25c. to two or three dollar nuggets. Then the abrasion which the nuggets have suffered tends to comminute them, making the gold finer than in its original state. The gold is generally bright, due to its grinding in the bed. In some places it is rusty, completely covered with iron oxide, in which case it will not amalgamate readily, but in most places the gold of a gravel deposit is smooth, bright and water-worn, taking the general character of the gravels with which it is found.

Development of Hydraulic Mining.

The methods of working these gravel deposits have undergone great changes, just as quartz mining has. In 1849, when gold was discovered in California, the first of these deposits were worked by gold pans. By that method, a man not working closely may be able to handle 1 or 1½ yards a day, if he pans rapidly.

Afterward they perfected the rocker, which is really a concentrating device for gravel. They dump the gravel into the screen plate on top, and by adding water wash the pebbles away. The punched sheet on the rocker varies with the different districts, generally between ¼ and ⅜ in., so that nothing but the finer gravel drops through to the screen below and then to the bed of the rocker. This is an inclined, canvas-covered surface over which the water flows;

FIG. 1. LA GRANGE PLACER MINE, TRINITY CO., CAL.

FIG. 2. UNDERMINING BANK WITH GIANTS. HEAD 600 FT.

by rocking it back and forth you get about the same effect as on a concentrating table. The concentrates are cleaned out and panned down. By this method a man is able to wash two or three times as much as he could with the pan alone.

Shortly after that, the sluice was developed. This consisted of a long, narrow trough; a 12-in. bottom with 6 or 8-in. sides, and wooden riffles, were used at that time. The first gravels were mined only where extremely rich, where the mass had been washed away and only the pay streak left. They placed the sluice in a depression or channel — in the creek bed if possible — making a small dam, and then shoveling the gravel into the sluice and letting the running water wash it away. In this sluice they had to pick out all the rock above 1 or 1½ in. size because such a small amount of water would not carry them away.

The method known as ground sluicing was next developed. A stream of water was conducted along the face of the gravel bank so that the cutting action of the stream would bring down the bank and carry away most of the material, leaving a small amount only to be shoveled into the sluice. Under the best conditions, two men by that method could handle 20 or 30 yards per day.

After a few years they developed the hydraulic giant, by which they could convey water under great pressure to the bank, and use it to cut down the gravel and also to carry it to the sluice; in this combination of hydraulic giant and sluice we see our present practice in hydraulic mining. The practice has grown from very small nozzles, one or two inches, and a pressure of 75 ft., up to a pressure of 625 ft. and a 9-in. nozzle. In hydraulic mining we must have sufficient fall to provide plenty of dumping ground at the end of the sluice so that the material can be carried away by the same stream that brought it down. In some placers this is not possible, and a hydraulic elevator is used. This is a pipe, built on the principle of an injector, which throws the gravel up to a sluice on trestles, and thus affords ample dumping ground. Where no dumping ground at all can be found, gold dredges are used; these require a soft bed rock, absence of large boulders, and a rather fine gravel.

Examination of Gravel Deposits.

The first thing an engineer would do in examining a gravel de-

posit would be to determine as nearly as possible the average gold contents per cubic yard of material. This can be done in several ways; in fact, gold-bearing gravels can be more accurately sampled than the best lode mine. Prospecting may be done by shaft sinking, by running drifts into the deposit, or by churn drill, operated either by steam power, like the Keystone or Cyclone drill, or by hand, like the Empire drill.

Shaft sinking yields a larger sample, which is therefore more accurate than a drill sample; on account of its excessive cost, however, you would not use shafts exclusively unless the deposits were less than 15 or 20, perhaps 40, ft. deep. Shafting in ground containing large amounts of water (known as running ground) is extremely difficult and costly, and the amount of water in some gravel deposits is excessive. In a 4×5 shaft I know of, we had a pump to handle 400 gal. per min., and were just able to sink to bed rock with that. In many such cases, the results are liable to be falsified by the running water's carrying more gravel into the shaft than its section would warrant. However, in gravel which can be handled without meeting an excessive quantity of water, it is most valuable to sink shafts to bed rock; this gives a good chance to ascertain the character of the bed rock, and to determine, by washing the gravel, where the gold lies. In placer deposits, it is rarely that the gold is distributed uniformly through the whole deposit from bed rock to the surface. In most cases it occurs very near the bed rock; the surface gravels are often of a finer character, due to the fact that the river was becoming more flat; they contain less gold and this is very fine. Again, alternating layers of rich and poor gravel may be found. In most cases, therefore, shafts are sunk, in addition to the boring of holes. One shaft is generally sunk in the center of an area of 15 or 20 drill holes; by then checking the drill holes against the shaft a factor may be computed for the former. In drilling, even with the most careful work, an error of 10 to 20 per cent. is possible. In some cases, where the deposit is shallow and there is plenty of water, it is advisable to open the deposit in a small way and wash several thousand cubic yards; the clean-up from such an operation gives a very exact idea of the value per cubic yard.

The next thing is to determine the physical condition of the deposit, whether loose or cemented, whether high, shallow, narrow or wide, all these factors being taken into account, together with the quantity, to see if it can be worked economically.

The next important factor is water supply; it is ascertained by surveys. The total amount of water that can be furnished to the mine, whether it is available for a long or a short period, whether it is owned by others or not, whether it must be brought over loose ground, whether it must be siphoned over depressions, conveyed by tunnels through mountains, the amount of money to be expended to bring the water to the mine, the deterioration, wear and tear, and the interest on the money so invested, must all be taken into account in figuring the cost per unit of water delivered at the mine. You must also consider for how many months in the year there will be sufficient water to run the mine. In California the rains begin in November and stop in the middle of April or first of May. If the mine is high enough in the mountains, snow water will carry it over well into the fall. The general mining season is 10 to 10½ months, while in Alaska it is only six weeks or two months, on account of the severe climate. In Canada they have four, five or six months. The length of season is a large factor in the case because the overhead expenses for management will be the same whether the mine is operated the whole 12 months or only a few weeks in the summer; yet whether or not the mine is operated at full capacity makes a very decided difference in the cost per cubic yard of material handled.

Another factor is the dumping space. Under ideal conditions the gravel bank will be at such an elevation that by means of a short sluice the tailings can be disposed of for years without additional handling, simply being carried by the water. As the dump expands the sluice is extended out over the dumped gravel.

The next factor is the bed rock. This is not so important in hydraulic mining as in dredging, when it must be soft so that the buckets can take it up to get all the gold; in hydraulic mining the best condition is that it be smooth and have some general slope. By careful surveys the old eroded channel can be located and the mine can be opened in such a way that the bed rock will always slope

FIG. 3. TAIL SLUICE, LA GRANGE MINE.

FIG. 4. TAIL SLUICE EXTENDED OVER DUMP.

upwards toward the gravel bank. The sluice must be placed at the lowest point so that the material will run toward it. If the bed rock is excessively soft, a great deal of gold catches in its natural riffles, and much of the bed rock must be cleaned up at the end of the season, to recover all the gold.

In opening a hydraulic mine it is important to make very careful surveys to determine the slope of the bed rock, in order to place the sluice in such a way that it will always be below the lowest point of the bed rock. To mine profitably a deposit of low grade, as most of them are — running from a few cents to 10 or 15c. per cubic yard —the mine must be opened in such a manner that the sluice will not have to be moved. La Grange mine was formed by the consolidation of a number of small mines. The channel is about 1½ miles long, is four miles from the present channel of the Trinity River and 700 ft. above it. They opened the mine on one side of the channel, and after working three or four years found that the bed rock dipped away. Their sluices were started in the bed rock, but the grade of the sluices carried the operation above bed rock, and into the gravel; hence they could not get the material into the sluice without other than hydraulic means. They then came down and opened the mine at the lowest point in the deposit. They started on a fault line and worked up; on one side is a greenstone and on the other side a very much metamorphosed slate which has slipped off the greenstone, leaving the latter perfectly smooth. By thus working on the junction of the two, they were able to keep the sluice lower than at any other place in the bed rock. They could then get down to the gravel and drive it into the sluice without handling any by other means. Even the cleanup material can be driven into the sluice by bringing giants in front of it and washing in the gravel.

Methods of Conducting Water.

The water supply for La Grange mine involves a ditch 40 miles long, over very rough country. This ditch carries about 3000 miner's inches; one inch is, by law in California, 1½ cu. ft. per min. In our calculations we use the volume one miner's inch affords in 24 hours, or about 80 cu. yd. of water. In this ditch is one siphon crossing Stewart's Fork. It is a 30-in. pipe-line, carrying a pres-

sure of 1100 ft. in the center. It is made of best steel and the walls are ½ in. thick; it is about 6700 ft. long. The water then runs through a flume four miles long and then through a mountain, by a tunnel 6000 ft. in length. This total length of about 40 miles was a very difficult and costly undertaking, warranted only by the great size of the gravel deposit. The gravel bank is over 1½ mile long, ½ mile wide and 650 ft. high at the center, and contains 650,000,000 cu. yd. in place.

Most gravel mines are worked on the reservoir system. The ditch is brought to a point near the mine, and pipe is laid to the mine at as great an elevation above the gravel as topography will allow. The reservoir will hold the capacity of the ditch for 4 or 5 hours. The advantage of the reservoir system is that it permits the use of an equipment in the mine consuming a much greater volume of water than the actual flow of the ditch; also by collecting water in the reservoir, opportunity is afforded to repair sluice, reset giants, repair pipe-line, or blast and remove heavy boulders.

In locating a reservoir, it is well to consider the effect of a possible sliding of the bank when part of the gravel has been washed away. In frequent cases a reservoir has been put on top of the deposit, or near to it, and after the deposit has been partially mined, the ground surrounding the mine has slipped and caused the reservoir to break and flood the mine. If possible, it is advisable to locate the reservoir in the solid country rock far enough away from the channel so that it will not be disturbed after the gravel is removed. At La Grange mine, this condition requires the main reservoir to be a long distance from the face, and as it is much cheaper to convey water in ditches than in pipe-lines, three reservoirs have been placed on the deposit. Eventually a new reservoir will have to be built because a ditch cannot be maintained long over the gravel.

Pipe-lines from the reservoirs are of the largest size that can be placed. The factors that govern the selection of the pipe are the life of the mine and its richness, or, more simply, how much money the company can well afford to put into a plant. At La Grange they use two pipe-lines of 30-in. diameter, which bring the water to within 150 ft. of the giants at a very slight loss of head. Small mines

are often compelled to use much smaller pipe, with a consequent great loss of head. Gates are placed at the reservoir, and also where the pipe tapers to 18 in. at the giant. The last mentioned gates could be used in an emergency to turn off the water, but they are not actually used in that manner; the water is turned off at the reservoir. In a pipe-line ¾ mile long it takes several minutes for the water to cease flowing. Gates are always closed with considerable care on account of the inertia of the water which might buckle or break the pipe.

Placing of the Giants.

The giants are placed at the ends of the pipe-line, and in no case would a pipe smaller than 15 in. be used with a nozzle of over 6 in. unless there were plenty of effective head to be wasted. The placing of the giants is a matter of some difficulty and requires a great

Fig. 5. Hydraulic Giant in Operation.

deal of experience, both to set them solidly and also to put them where they will be most effective against the bank. The effective pressure at the giant must be in proportion to the hardness of the bank and to its height. With a 650-ft. bank, the giants have to be placed quite a distance from the face, because as the toe of the bank is washed away the boulders dropping down jump two or three hundred feet across bedrock before coming to rest. At La Grange we

have 6 or 8 ft. of very rich gravel and 75 or 80 ft. of a hard gravel cemented by iron oxide; this, when first exposed, is almost as durable as concrete, but it is weathered easily and the water breaks it down. This is possible owing to the high head of water, while we are still able to place the giants far enough back from the danger zone.

To do good work the giants must have such a head that their cutting effect will always be in excess of the carrying capacity of the sluice. That is, it should be possible to cut down and bring to the sluice more gravel than the same amount of water will transport through the sluice. That demands a very high effective head on the mains, which, in a great number of cases, is not obtained. If an excess cutting effect is available, the giants can at any time be turned away from the sluice so as not to crowd the sluice above its capacity.

Sluice Construction.

The next important feature is the sluice and bulkhead. At La Grange we have boulders which weigh as much as 15 or 20 tons.

Fig. 6. Bulkhead to Control Gravel Rushes.

The mouth of the sluice is 6 ft. wide in the clear and 18 ft. in height. With the excessive force of our giants and the great amount of water, we are able to send boulders clear through the sluice which will just pass the head of it; we have sent boulders through which

weigh 8 or 10 tons. The bulkhead is reinforced against wear by 18-ft. lengths of 40-lb. steel rails. The giants are placed far enough back so that they command the entrance to the sluice. They generally work in pairs, first cutting and then by swinging around and following the material they make a "double header," adding water

FIG. 7. HEAD OF SLUICE WITH "BOOSTER GIANT."

to that which has cut the gravel. By these big rushes the heavy material is carried into the sluice.

In the early days riffles were made of round poles of 1 to 3 in. diameter, nailed transversely, or placed longitudinally with offsets. California then developed the use of riffle blocks, transverse sections of pine, generally 12 × 12, and from 3 to 12 or 14 in. in depth, as

determined by the experience at each mine; that is, they generally put in a new set at the beginning of a season and made them deep enough so that the friction of the gravel would not entirely wear them away before cleaning-up time in the spring. As the sluices got larger and the amount of water in them was increased, at some mines in California they used blocks 14 × 14 and 16 in. deep. The

FIG. 8. LINING SLUICE WITH SCRAP RAIL.

fibre being placed at right angles to the water, the blocks have much more resistance than when placed as round poles.

At La Grange mine they found that pine blocks wore out so

rapidly, and that so great a proportion of time was lost in replacing them, that some other method must be devised, to make a permanent riffle. Scrap iron over wood was tried. Then they adopted the standard 40-lb. steel rail, which has been in use for six years now. They are placed transversely across the bottom, spaced 5 in. center to center, and held in place by lugs, or blocks, bolted to the rail; these lugs fit into the depression of the next rail, and then by laying other rails on the two sides to hold them down, we make perfectly rigid riffles. They are placed over riffle sticks, 2×6, set on edge. The steel rails take the wear of the gravel, while the riffles catch the gold. We have used the regular steel rail, a high-carbon steel rail, and a wrought-iron rail, but we find the manganese steel best. The average railroad rail will be worn out in about two-thirds of the season.

Special manganese steel rails are now used. They cost $2\frac{1}{2}$ to 3

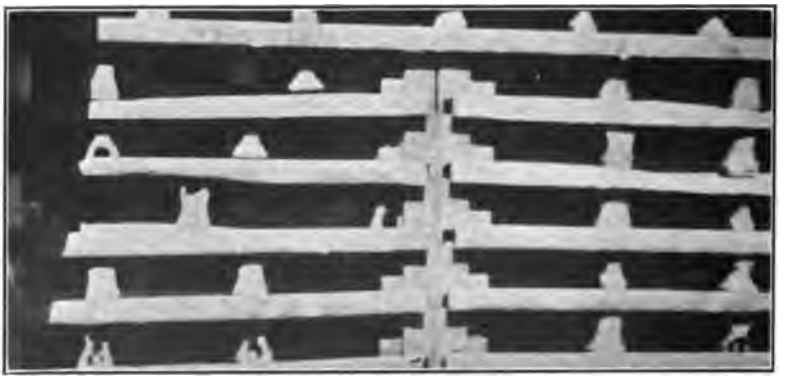


FIG. 9. METHOD OF LAYING RAILS IN SLUICE.

times more than the ordinary steel rail; still they are a great saving and I think will be used extensively in the future. Rails cost $10 per ton freight to Reading, Cal., and haulage from the railroad is $1\frac{1}{2}$c. per lb. to the mine. Taking into account the longer wear of the manganese rails at no greater charge for freight, they are proving economical.

In designing a sluice, then, we must study, from a hydraulic standpoint, to get the perimeter that gives least friction and highest velocity. The main point is to get the greatest capacity per unit quantity

of water. This can be done only by building the sluice so as to get the right depth of water in the sluice at the right grade. The grade, in most cases, is dependent on local conditions; that is, a sluice of average size would generally have an 8-in. grade, seldom less than 6-in. grade, per 12 ft. Grade is generally stated by the box, which is 12 ft. long. In the La Grange sluice we allow 6 in., but by permitting the gravel to accumulate in the sluice, and by building up the sides, we can make an 8-in. grade. While cutting down the material with the giants, all will not be carried to the head of the sluice; neither will the material have a high velocity in the direction of the sluice when it first enters. In order to start the material down the sluice it is advisable to build a high bulkhead, to afford a high head of water, so that it will rush through. Then by building up the sides of the sluice near its head we can make a high grade and get the material started down the sluice. The head of the sluice thus controls the capacity of the entire operation, and in every economical way we try to make the capacity per unit quantity of water as great as possible.

HYPERBOLIC FUNCTIONS AND THEIR APPLICATION TO PROBLEMS IN ELECTRICAL ENGINEERING

BY J. H. MORECROFT.*

At a meeting of the Electrical Engineering Society of Columbia University, on Nov. 7, 1912, we were fortunate in having for lecturer Dr. A. E. Kennelly, Professor of Electrical Engineering in Harvard University, Past President of the A. I. E. E. His subject was one in which he is especially interested and in which he has done pioneer work, "The Application of Hyperbolic Functions to Problems in Electrical Engineering." Few engineers even know what a hyperbolic function is, and fewer still are able to use the hyperbolic trigonometry in solving problems of power transmission, telephone lines, etc. Yet, as the lecturer showed, there is nothing more mysterious about a hyperbolic sine or cosine than about the ordinary circular sine or cosine. It is not my intention to give a verbatim report of Dr. Kennelly's lecture, but I will try to show how simply he explained what hyperbolic trigonometry is, and of what value it may be to an engineer who can use it. I have extracted freely from Dr. Kennelly's book for illustrations.

Trigonometry, for the average technical man, has to do only with the simple ratios of sides of a right-angled triangle, the angles being measured in radians, or degrees, the radian being that angle the subtended arc of which is equal to the radius of the circle. All of our ideas of angles are based on this fundamental idea of a unit angle, and the ordinary trigonometric functions are defined by the ratios of certain lines constructed on this circle diagram. Now is there any reason why we should not derive a set of relations between corresponding lines constructed upon a hyperbolic diagram, and use these relations, if they prove to be of practical utility? It is my hope to show both the simplicity of the hyperbolic functions and the uses to which they may be put; if this can be done the reader will gain a valuable tool with which to solve problems in long distance power transmission and telephone lines, and will also

* Assistant Professor of Electrical Engineering, Columbia University.

be able to understand papers and discussions which he now passes over, only because, instead of the familiar *sin* α and *cos* α, he sees their hyperbolic cousins *sinh* β and *cosh* β.

Figs. 1 and 2 show how nearly alike circular and hyperbolic angles really are. In Fig. 1 we have a circle of radius equal to unity, OA, and Fig. 2 gives the corresponding rectangular hyperbola having the same radius, OA. (A rectangular hyperbola is one of which the asymptotes are lines making an angle of 45° with the axis.) Now a measure of the circular angle AOB (Fig. 1) is given (in circular radians) by the ratio of the length of the arc AB to the average length of the radius vector OA; in the circle this radius vector is constant. In the hyperbola (Fig. 2) the hyperbolic angle AOB is measured by the ratio of the length of the arc AB to the average length of the radius vector, which is constantly changing as the arc increases in length. In Fig. 2 this average radius is shown by OC and the hyperbolic angle AOB (in hyperbolic radians, not circular radians) is given by the ratio of the length of AB to OC.

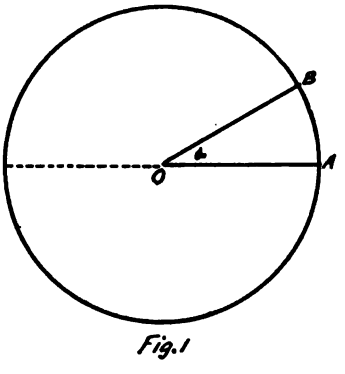


Fig. 1

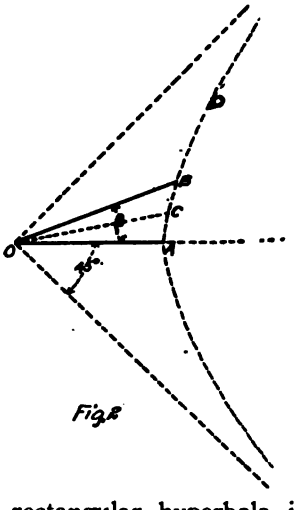


Fig. 2

The difference between circular angles and hyperbolic angles is due to the fact emphasized above; as the circular arc increases, its radius vector remains constant, but as the hyperbolic arc increases, its radius vector continually increases. A certain length of arc on the hyperbola would thus subtend a smaller hyperbolic angle than

an equal length of circular arc would subtend circular angle. If, for example, in Fig. 1, the length of the circular arc AB is just equal to the radius OA, the angle subtended is one circular radian, or 57° +. If, however, in Fig. 2, the arc AB is increased to some value AD, such that the length of AD is just equal to the mean radius vector of the arc, the hyperbolic angle DOA is only one hyperbolic radian. Yet $AD = 1.318 \times OA$. When β, Fig. 2, is just equal to one hyperbolic radian, in circular measure it is only 0.65 radian, or about 37°. This difference in measurement of a hyperbolic angle β, in hyperbolic radians and in circular radians, must be kept in mind.

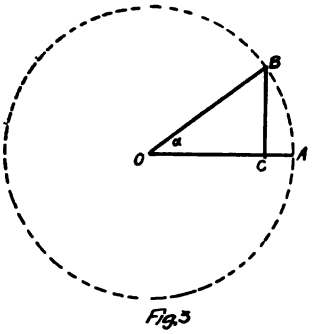


Fig. 3

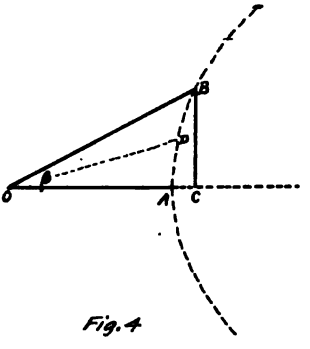


Fig. 4

In Figs. 3 and 4 are shown two constructions exactly similar, but one of them is carried out on a circle and the other on a rectangular hyperbola. The measure of the circular angle α (Fig. 3) is found by the ratio of AB to OA, while the measure of the hyperbolic angle β (Fig. 4) is found by the ratio of the length of arc AB to the mean radius vector, shown at OD. In both figures a perpendicular is dropped from B to the axis and intersects at the point C. Now we can derive the ordinary trigonometric relations for sine, cosine, etc. The hyperbolic sine is abbreviated to *sinh*, the hyperbolic cosine to *cosh*, etc.

In (Fig. 3)	In (Fig. 4)
$\sin \alpha = BC \div OA$	$\sinh \beta = BC \div OA$
$\cos \alpha = OC \div OA$	$\cosh \beta = OC \div OA$
$\tan \alpha = BC \div OC$	$\tanh \beta = BC \div OC$
etc.	etc.

Thus it is seen that the hyperbolic functions are found in exactly the same fashion as are the circular functions. There is, however, a very marked difference in the values of the two sets of functions; thus, as the circular angle increases through values of π, 2π, etc., the functions undergo periodic changes, but in the hyperbolic trigonometry, as the arc AB increases, all of the functions take either increasing or decreasing values, but do not go through periodic changes.

When the hyperbolic arc becomes large, the point B evidently lies very nearly on the 45° line, the asymptote of the hyperbola, and when this limit is reached evidently $tanh\ \beta = 1$. But the cosh and sinh are evidently approaching infinity as the hyperbolic arc continues to increase, and are also approaching each other in value.

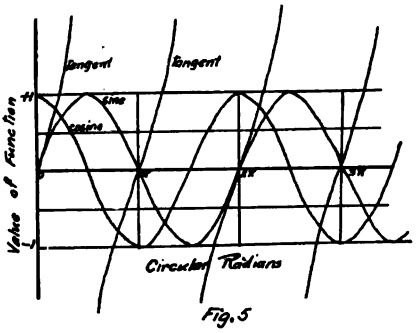


Fig. 5

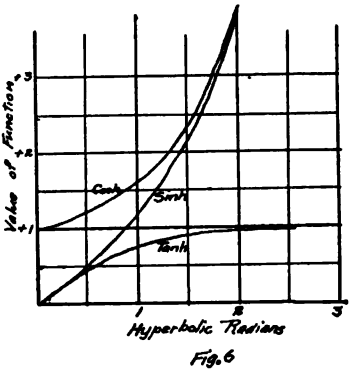


Fig. 6

Fig. 5 shows how the sine, cosine, and tangent go through their periodic changes as the circular angle increases, and Fig. 6 shows how the sinh, cosh, and tanh change with an increase of hyperbolic angle.

All of the relations which are known to exist between the functions of circular angles may be at once transformed to express similar relations between hyperbolic functions. When the circular function is involved in the first power only, a direct transformation may be made at once. Thus, $sin\ 2\alpha = 2\ sin\ \alpha\ cos\ \alpha$ transforms into $sinh\ 2\beta = 2\ sinh\ \beta\ cosh\ \beta$. When the circular function is involved to the second power, as $sin^2\alpha + cos^2\alpha = 1$, the corresponding hyperbolic relation generally involves some change in sign; thus, $cosh^2\beta - sinh^2\beta = 1$.

This brief explanation serves to show what the hyperbolic functions of simple angles are, and how their interrelations may be obtained from the corresponding formulas in circular trigonometry.

Utility of the Hyperbolic Functions.

The question now arises, in what kind of electrical problems is it necessary to use the hyperbolic functions? It is not absolutely necessary to use these functions in any electrical problem, because approximate algebraic formulas have been derived which serve for *approximate solutions,* but there is a certain class of problems in which it is necessary to use hyperbolic functions if *accuracy* is desired. Problems in which the current has a continually changing value in consecutive sections of the line, due either to leakage between the two sides of the line or to the capacity of the line, can be accurately solved only by the use of hyperbolic trigonometry.

To make this distinction clear I give a few examples with diagrams of current and voltage. Figures 7, 8, 9, and 10 show the

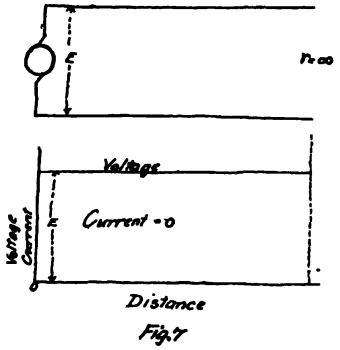


Fig. 7

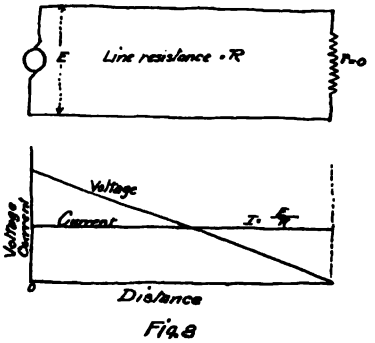


Fig. 8

current and voltage curves for a direct-current line in which there is perfect insulation between the two wires, so that current can get from one wire to the other only through one of the loads. Fig. 7 refers to an open-circuited line; the current is everywhere zero and the potential difference between the wires is everywhere equal to that of the generator. Fig. 8 represents the same circuit with a resistance of zero ohms across the end of the line. The total line resistance is R ohms and the current which flows is equal to $E \div R$. This current is exactly the same throughout the line and an ammeter placed at the beginning, middle, or end of the line would

indicate the same number of amperes. The current and e.m.f. curves for these two circuits are simple straight lines, and problems of this type ordinary algebra solves exactly.

In Figs. 9 and 10 are shown two conditions of loading of a d.-c. line: in Fig. 9 a single concentrated load is assumed at the end of

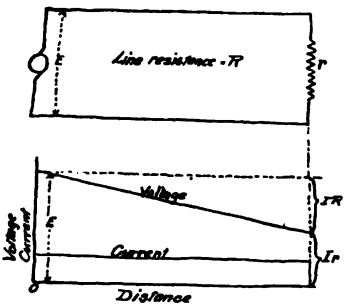


Fig. 9

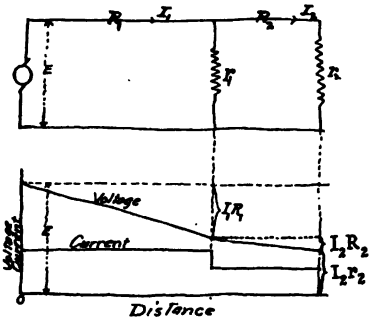


Fig. 10

the line, and in Fig. 10 two loads are assumed, one at the end and one at the middle. The current and e.m.f. curves are still straight lines, and algebraic equations serve for the accurate solution of the current and e.m.f. at any point in the line. Of course, when there are several loads at different points of the line, the algebraic equations become a little complicated, but still simple algebra suffices for an accurate solution. An alternating-current line of perfect insulation and *negligible capacity,* can be easily solved in just the same way as the d.-c. problems given.

Now suppose a d.-c. line in which there is not perfect insulation between wires; e.g., there may be a current leaking across the line by the paths made up of the two insulators and cross arm. In an overhead line, or in the case of a cable, the insulation between wires may be weak, so that there is a current flowing through this insulation throughout the length of the line. Such are called *leaky lines,* and their problems can be solved accurately only by using hyperbolic trigonometry. An a.-c. line, in which the capacity between wires is appreciable, also requires hyperbolic functions for its accurate solution.

These two cases, d.-c. lines with leakage and a.-c. lines with capacity, it will be noted involve a continually varying current

throughout the length of the lines, the current generally being less at a greater distance from the generator than close to it. By reference to Figs. 11 and 12 this point is seen to be true; the leakage

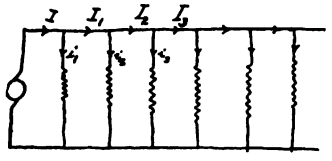


Fig. 11.

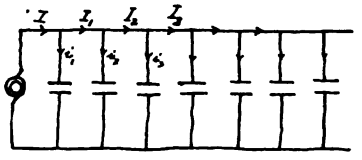


Fig. 12.

and capacity effects, which are really distributed uniformly throughout the line, are here shown lumped. Suppose a line 50 miles long having a leakage path of r ohms per mile of length; Fig. 11 would then have, say, 50 paths of r ohms to represent the line, or a more accurate representation would be obtained by assuming 100 paths of resistance $\frac{1}{2}$ r ohms, and so on.

Now in Figs. 11 and 12, evidently $I_1 = I - i_1$, $I_2 = I_1 - i_2$, $I_3 = I_2 - i_3$, etc. Such lines, therefore, carry a current which continually changes throughout the length of the line, being greater or less in one section than it is in neighboring sections. Fig. 13 shows the

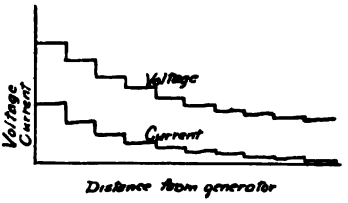


Fig. 13.

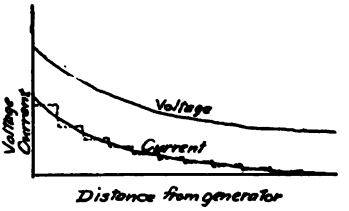


Fig. 14.

possible e.m.f. and current curves for the two lines shown in Figs. 11 and 12, while Fig. 14 shows the possible e.m.f. and current curves for the real lines, of which those shown in Figs. 11 and 12 are only approximations. In light dashed line in Fig. 14 is shown the current curve from Fig. 13; by comparison of these two it is seen how nearly the irregular line corresponds to the smooth line. It is evident that by assuming a sufficient number of sections in the irregular line, its current and e.m.f. relations may be made very nearly like those which exist in actual transmission or telephone

lines, which are represented generally by smooth lines. It is because of this fact that experimenters are able to build, in the laboratory, artificial lines, in sections, the behaviour of which will be similar (to any desired degree) to that of actual lines. It was in this way that Prof. Pupin studied the action of telephone lines and by means of such a line Dr. Kennelly has done a deal of accurate work on power transmission lines.

The curves of e.m.f. and current in Fig. 14 are hyperbolic functions of the distance along the line, and all leaky lines and a.-c. lines with appreciable capacity have e.m.f. and current curves of similar form. From these few illustrations the reader can see how useful and necessary the hyperbolic trigonometry is if accurate solutions are required for such lines.

It has been customary to avoid the use of the hyperbolic trigonometry when dealing with long lines by making certain rough approximations. For instance, the entire leakage current has been assumed to flow across the line at its middle point; or perhaps half the leakage current at the beginning of the line and half at the end, has been assumed. In the case of a.-c. lines, the entire capacity has been lumped halfway along the line, or perhaps one quarter of it at either end of the line and one half at the center of the line. The reason for using these approximations has probably been twofold: the average engineer felt shy about using hyperbolic functions and, secondly, accurate and full tables of the values of hyperbolic functions have been available only lately. New tables are constantly being compiled by Dr. Kennelly and his assistants, so that before long complete tables will be accessible to every one.

That the curves of current and e.m.f. in long uniform lines would by hyperbolic curves was predicted by Sir Oliver Heaviside; the theoretical treatment is given in Vol. I of his "Electromagnetic Theory," published in 1893. A partial demonstration will be given here to show how the results are obtained, but I will omit that portion which is strictly mathematical. Suppose a d.-c. line be considered, for a small part of its length only, as shown in Fig. 15.

Let: r = conductor resistance per km.

$g = 1 \div r_x$, where r_x = the insulation resistance between wires, per km.

e = voltage between wires at points considered.

i = current in line at point considered.

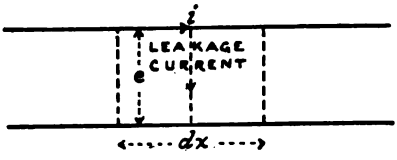


Fig. 15

Then in the element of length considered, the leakage current will be *egdx* amperes, and the drop in voltage along the elements of line will be *irdx* volts, so that we may write the differential equations:

$$-de = irdx$$

$$\frac{de}{dx} = -ir \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

and $-di = egdx$

$$\frac{di}{dx} = -eg \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

By differentiating (1) and (2) again with respect to x, we obtain:

$$\frac{d^2e}{dx^2} = -r\frac{di}{dx} = gre \quad \ldots\ldots\ldots\ldots (3)$$

$$\frac{d^2i}{dx^2} = -g\frac{de}{dx} = gri \quad \ldots\ldots\ldots\ldots (4)$$

In Heaviside's writings it is shown that the solutions of these two equations are:

$$e = A\ cosh\ (x\sqrt{gr}) + B\ sinh\ (x\sqrt{gr}) \ldots\ldots\ldots (5)$$

$$i = C\ cosh\ (x\sqrt{gr}) + D\ sinh\ (x\sqrt{gr}) \ldots\ldots\ldots (6)$$

While it may not seem apparent, the quantity $\sqrt{gr}$ is really a hyperbolic angle; it is the number of hyperbolic radians represented by one kilometer of line. The complete expression $(x\sqrt{gr})$ is therefore the number of hyperbolic radians represented by the length x of the line.

Now put: $\alpha = \sqrt{gr}$

l_1 = distance from beginning of line to point x.

$r_0 = \sqrt{r \div g}$

The constants A,B,C, and D depend upon the voltages and cur-

rents at the beginning and end of the line. If we designate these currents and voltages by E_A, E_B, I_A and I_B, where the subscripts $_A$ and $_B$ designate the beginning and end of the line respectively, then (5) and (6) reduce to:

$$e = E_A \cosh l_1\alpha - I_A r_o \sinh l_1\alpha \quad \ldots\ldots\ldots\ldots (7)$$

$$i = I_A \cosh l_1\alpha - \frac{E_A}{r_o} \sinh l_1\alpha \quad \ldots\ldots\ldots\ldots\ldots (8)$$

These two equations serve for the solution of voltage and current at any point along the line when the voltage and current are known at the sending end. If, on the other hand, these quantities are known at the receiving end we then employ other equations, using these values:

$$e = E_B \cosh l_2\alpha + I_B r_o \sinh l_2\alpha \quad \ldots\ldots\ldots\ldots (9)$$

$$i = I_B \cosh l_2\alpha + \frac{E_B}{r_o} \sinh l_2\alpha \ldots\ldots\ldots\ldots\ldots (10)$$

where l_2 is the distance from the receiving end to the point at which e and i are desired.

Of course, in special cases these equations may be much simplified; e.g., suppose the receiving end is open-circuited. This makes $I_B = 0$; whence (9) and (10) reduce to:

$$e = E_B \cosh l_2\alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

$$i = \frac{E_B}{r_o} \sinh l_2\alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

The resistance offered by the line from the point considered to the end of the line is equal to

$$R_f = \frac{e}{i} = r_o \coth l_2\alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

We may now suppose this point moved back as far as the beginning of the line, when $l_2 = L$; then $e = E_A$ and $i = I_A$, and hyperbolic angle $l_2\alpha$ becomes $L\alpha$, and this measures the hyperbolic angle of the complete line; we call it θ.

Hence, $$E_B = \frac{E_A}{\cosh \theta} = E_A \operatorname{sech} \theta \quad \ldots\ldots\ldots\ldots\ldots (14)$$

and $$R_f = r_o \coth \theta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

This resistance R_f is that which would be measured in a Wheat-

stone bridge if the line, open at its receiving end, were put in the bridge as the unknown.

Or again, suppose the receiving end to be short-circuited, in which case $E_B = 0$. Then $e = I\ r_0 \sinh l_2 \alpha$,

$$\text{or, } I_B = \frac{e}{r_0 \sinh l_2 \alpha}$$

Suppose next that we take the complete length for l_2, so that $e = E_A$ and $l_2 \alpha = \theta$.

$$\text{Then, } I_B = \frac{E_A}{r_0 \sinh \theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (16)$$

The current at the sending end of the line may be obtained by use of equation 7, putting $e = 0$.

$$I_A = \frac{E_A}{r_0 \tanh \theta} = \frac{E_A}{r_0} \coth \theta \quad \ldots\ldots\ldots\ldots\ldots (17)$$

We can also derive $R_g = r_0 \tanh \theta$ ..... (18)

where R_g is the resistance of the short-circuited line.

In similar way the current and voltage at any point in the line, for any value of receiving circuit resistance, may be found.

In the case of very long lines, or lines having a certain resistance in the receiving circuit, the voltage and current fall off *exponentially* and hyperbolic functions need not be used. If the hyperbolic angle subtended by the whole line is, perhaps, 5 radians, then

$$\sinh l\alpha \text{ is proportional to } \frac{\epsilon^{l\alpha}}{2}$$

and then we get the relation:

$$i = I_A \frac{\epsilon^{-l\alpha}}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

In such expressions as, attenuation $= \epsilon^{-\alpha l}$ this α, used as an exponent, is what we call the characteristic hyperbolic angle per unit length of line, and evidently the angle we call θ is the same as αl in the above expression, $\epsilon^{-\alpha l}$. The quantity r_0 is ordinarily called the *surge resistance* of a line. It is the resistance which would be measured in a Wheatstone bridge with an infinitely long cable of the constants r and g. It may be obtained for a short line by getting the geometrical mean of the open-circuit and short-circuit

resistance or $r_0 = \sqrt{R_t R_g}$. Also $\theta = tanh^{-1} \sqrt{R_g \div R_t}$, and α may be obtained by the relation, $\alpha = \theta \div L$.

The conductor resistance per unit length is then found by:

$$r = \alpha r_0 \ldots\ldots\ldots\ldots\ldots\ldots (20)$$

and the leakage path conductance by

$$g = \alpha \div r_0 \ldots\ldots\ldots\ldots\ldots\ldots (21)$$

Hence, by measuring the resistance of a long line, (say an ocean cable) with the distant end first short-circuited and then open-circuited, the true conductor resistance and leakance may be found. A certain line, e.g., gave an open-circuit resistance of 5912 ohms and a short-circuited resistance of 4434 ohms.

Hence $r_0 = \sqrt{5912 \times 4434} = 5120$ ohms.

$$\theta = tanh^{-1} \sqrt{4434 \div 5912} = 1.317 \text{ hyp-radians.}$$

The line was 800 km. long; hence the attenuation constant $\alpha = 1.317 \div 800 = 0.001646$ hyp-radians per kilometer.

If the values of r and g had been computed as a novice would naturally do it, i.e., say $r = R_g \div L$ and $g = R_t \div L$, the results obtained would have been inaccurate by 30 to 40 percent. A short line would have given proportionately less error, and in fact where θ is less than 0.1 hyp-radian, accurate solutions may be obtained by using θ instead of $sinh\,\theta$, etc., in which case the hyperbolic functions need not be employed at all.

If, e.g., the line mentioned above were only 50 km. long, its total hyperbolic angle would be only $0.001646 \times 50 = 0.08230$ hyp-radian, and it would not be necessary to use hyperbolic functions to solve the line fairly accurately. In most power transmission lines it is unnecessary to use hyperbolic functions to get accurate results, but they are necessary in the solution of such problems as long distance telephony and telegraphy. The question of upper harmonics in long distance power lines, however, can be solved accurately only by the use of hyperbolic functions.

Application to Alternating-Current Lines.

So far we have dealt only with direct-current lines, or else alternating current lines which obey the same laws as a direct current line, i.e., those which have no inductance nor capacity.

When we come to compute wave propagation over ordinary alternating-current lines, we have two things to consider, namely, *attenuation* and *phase shifting,* whereas in the previous problems we considered only attenuation. An alternating current, or e.m.f. wave, as it travels along a line having resistance, inductance and capacity, not only suffers diminution in its magnitude but its phase with respect to the phase of the sending generator is changed, so that, for example, the current at the end of a long line passes through its maximum value either before or after the current at the beginning of the line passes through its maximum value. To express this combined change in magnitude and phase we have to use *complex quantities* which are, of course, more or less familiar to the average engineer.

In the direct-current problem, we derived certain relations, such as $e = E_B \cosh l_2 a$, and it was remarked then that this hyperbolic angle a is a real quantity, signifying decay in the current or e.m.f. I shall not introduce here the mathematical derivation, but shall take it from standard works that in an a.-c. line having resistance, inductance, and capacity, the previously derived equations hold good, but the angle a must be properly interpreted.

For the a.-c. line we can use all of the formulas derived for the d.-c. line, only interpreting properly the letters used. For example, let us take an a.-c. line for which:

r = ohms per km.
l = inductance per km.
g = leakage conductance per km.
c = capacity per km.
f = frequency of impressed e.m.f.
$\omega = 2\pi f$
$z = r + j\,2\pi f l$
$y = g + j\,2\pi f c$

Then the characteristic hyperbolic angle per km. of this line is obtained by:

$$a = \sqrt{zy} = \sqrt{(r + j\omega l)\,(g + j\omega c)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (22)$$

from which it may be seen that a is complex. Writing $a = a_1 + j a_2$ we separate a into its two parts. The significance of these two

parts is interesting; the e.m.f., or current wave, is attenuated per km. of line in the ratio of $1 : e^{-\alpha_1 l}$, and the phase of the wave is changed per km. of line by the amount α_2, where α_2 is expressed in circular radians.

Evidently $\alpha_1 = \sqrt{rg - \omega^2 lc}$ .....(23)

and $\alpha_2 = \sqrt{\omega(rc + gl)}$ .....(24)

Suppose now that the voltage and current at the beginning of an a.-c. line are known, and that its constants also are known, and we wish to compute the voltage and current at some point on the line distant l_1 from the beginning. We may use at once equations (7) and (8).

$$e = E_A \cosh l_1\alpha - I_A z_0 \sinh l_1\alpha \quad \ldots\ldots(25)$$

$$i = I_A \cosh l_1\alpha - \frac{E_A}{z_0} \sinh l_1\alpha \quad \ldots\ldots(26)$$

It will be noticed that the r_0 of equations 7 and 8 has been changed to z_0; this is because of the fact that in the a.-c. line it is *impedance* which retards the flow of current and not alone resistance. So in place of the r and g we used in the d.-c. line, we now use z and y, which have been defined in a previous paragraph.

Just as r_0 was put equal to $r \div g$, so here we put:

$$z_0 = \sqrt{\frac{z}{y}} = \sqrt{\frac{r + j\omega l}{g + j\omega c}} \quad \ldots\ldots(27)$$

Now in using such equations as (25) and (26) it is evidently necessary to have tables of the hyperbolic functions of complex angles. Also it is evident that complete tables of such functions must be very extensive, because not only can such angles vary in magnitude, but the ratio of α_2, the imaginary part of the angle, to the real part α_1, may go through a wide range. Partial tables of these functions have been published by various writers and others are in process of construction.

In computing these complex functions, much time and labor are involved, as may be seen from formulas (28) and (29), which are the two from which the sinh and cosh are computed:

$$\sinh (x \pm jy) = \sinh x \cosh jy \pm \cosh x \sinh jy$$
$$= \sinh x \cos y \pm \cosh x \sin y$$

$$= \sqrt{\cosh^2 x - \cos y} \angle \pm \tan^{-1} (\coth x \tan y) \quad (28)$$

$$\cosh (x \pm jy) = \cosh x \cosh jy \pm \sinh x \sinh jy$$

$$= \cosh x \cos y \pm j \sinh x \sin y$$

$$= \sqrt{\sinh^2 x + \cos^2 y} \angle \pm \tan^{-1} (\tanh x \tan y) \quad (29).$$

From these two formulas it may be seen that the hyperbolic functions of complex angles are *directed* magnitudes; e.g., $\sinh (x + j y)$ is equal in magnitude to $\sqrt{\cosh^2 x - \cos^2 y}$, and this magnitude extends in a direction such that the angle included between it and the reference line has a tangent equal to $(\coth x \tan y)$.

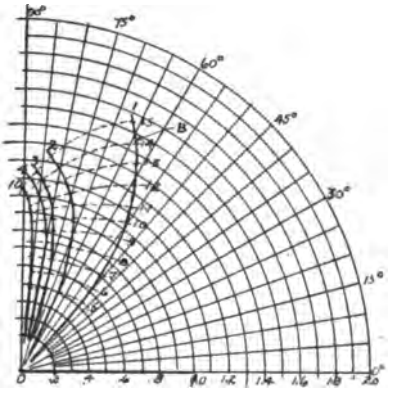


Fig. 16

Loci of Sinh (x + jy) for ratios of imaginary to real equal to 1, 2, 3, 4, and 10.

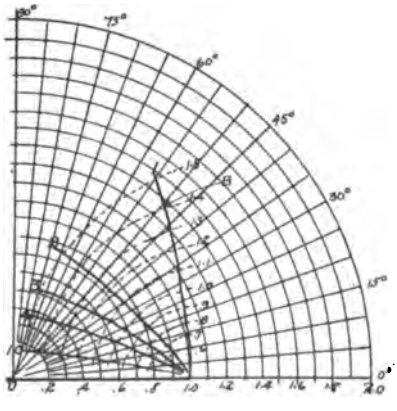


Fig. 17

Loci of Cosh (x + jy) for ratios of imaginary to real equal to 1, 2, 3, 4, and 10.

Tables of directed magnitudes may always be given in the form of charts; some charts of these complex functions have been prepared and others are being constructed at present by Dr. Kennelly

and his assistants. Four such charts are given in Figs. 16-19. Suppose it is desired to find the value of *sinh* (1 + j1). The ratio of imaginary to real is 1, and the magnitude of the angle is 1.41; hence the value of *sinh* (1 + j1) is found on chart 16 by following

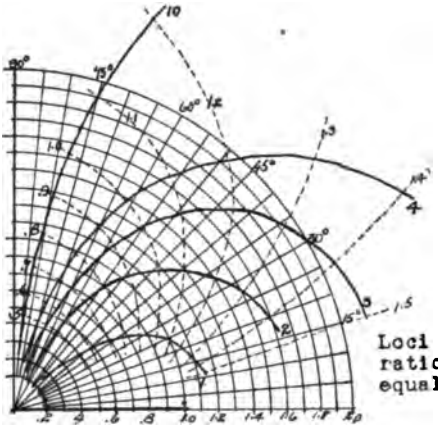


Fig. 18.

Loci of Tanh (x + jy) for ratios of imaginary to real equal to 1, 2, 3, 4, and 10.

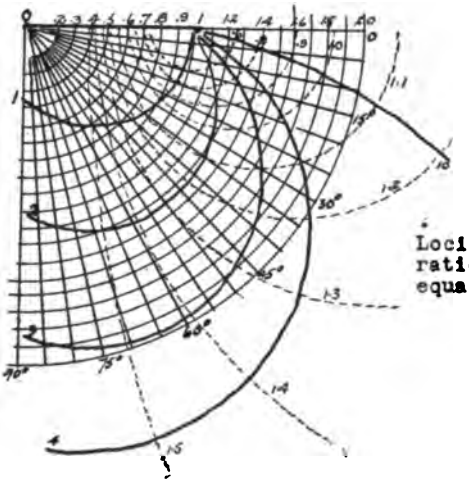


Fig. 19.

Loci of Sech (x + jy) for ratios of imaginary to real equal to 1, 2, 3, 4, and 10.

up the heavy line marked 1 (numbers on ends of heavy lines signify ratio imaginary ÷ real) as far as the dotted line 1.41 (this point being estimated between the dotted lines 1.4 and 1.5). Then the value of the sinh is read from the chart as equal in magnitude to

OB at the angle *BOA*. In the case given this proves to be about 1.44 at the angle 63.7°. In Fig. 17 it is seen that the cosh of the same complex angle is equal to about 1.29 at the angle 49.5°.

Now for an open-circuited, d.-c. line we had the formula (14) $E_B = E_A \div \cosh\theta = E_A \operatorname{sech}\theta$, where θ was the d.-c. length of the line in hyperbolic radians. This same formula holds for a.-c. lines, but, of course, θ becomes complex in this case. If the line had a total angular length of $(1+j1)$, from Fig. 19 the value of *sech* $(1+j1)$ is found to be about 0.77 at the angle $-49.5°$, so that if 100 volts were impressed at the beginning of such a line the voltage at the open receiving end would be $100 \times 0.77 \angle -49.5° = 77$ volts, lagging 49.5° behind the impressed voltage.

If, however, the hyperbolic angle of the line were $(0.2+j0.8)$ the value of *sech* θ is found from the chart to be about $1.38 \angle -11°$. Hence for this line, $E_B = E_A \times 1.38 \angle -11°$ or 138 volts lagging 11° behind impressed voltage.

It is not possible, of course, to take up in detail the many problems which are so easily solved by the use of hyperbolic trigonometry, but it is hoped that this brief article may serve to indicate in a general way what the hyperbolic functions are and how they may be of assistance to the engineer engaged in the problems of long distance lines. For a complete treatment of the subject the reader is referred to Dr. Kennelly's book, "The Application of Hyperbolic Functions to Electrical Engineering Problems."

REINFORCED CONCRETE STUDIES.

I. THE HOLLOW DAM OF THE BUTTRESS TYPE.

BY J. K. FINCH AND W. F. THOMAN.

This paper is the first of a proposed series which will discuss the design and method of construction of representative structures in reinforced concrete. While the various text-books on concrete state in detail the design of structural units, beams, slabs, etc., they are to a large extent deficient in detailed study of the structures themselves, and in the various practical considerations which lead to certain features in the design.

Concrete-steel is a relatively new material and the design of structures involving its use has not yet reached that state of standardization which exists, for example, in structural steel work. Certain tables and rules have been devised but in the details of design much is left to the ingenuity and practical skill of the designer. The nature of the material and its method of fabrication are almost entirely responsible for this. The manufacture of steel is carried out in a shop under ideal conditions for fabrication and inspection, and its erection is merely a matter of assembling and putting together the various units that go to make up the structure. Reinforced concrete, on the other hand, is manufactured in place, in the field, sometimes under far from ideal conditions, and by labor that is, for the most part, unskilled. Its supervision should always be in the hands of experienced and competent men. Unfortunately, this is not always the case and oftentimes the caliber of the construction organization will have considerable influence in determining the details of design.

The forms, or molds, for the concrete exert even a greater influence. The cost of the forms is usually from one-half to two-thirds of the entire labor cost in a concrete structure, and very often economy of materials must be sacrificed to the simplification of the form work. As a general rule, all details should be made as simple as possible. Where the erection is to be beyond the control or supervision of the designer, great caution should be exercised in designing and delineating small but important details which may

appear unimportant to the man in the field. The monolithic character of concrete will also introduce stresses due to continuity which may sometimes be used to advantage, but must always be provided for. Contraction and expansion must also be taken care of by the designer and not left to the ingenuity of the erector.

In this and the following papers, the notation, formulæ, unit stresses, etc., recommended by the Joint Committee on Reinforced Concrete will be mainly followed.*

General.

Types.— Four or five types of hollow concrete dams have been developed,[1] but the most widely used and the original form is the buttress type, which is here discussed. This form is patented by the Ambursen Hydraulic Construction Co., Ltd., of Boston. Its use is therefore controlled by this company and its design is taken up here simply because it offers a good opportunity to bring out the methods followed in the design of a structure of this type.

Historical.— The first dam of this kind was built at Theresa, N. Y., in 1903, and was designed by Messrs. Ambursen and Sayles, of Watertown, N. Y. Since that time, over 75 dams have been built, varying in height up to 150 ft. and in length up to 1200 ft.

Advantages.— It is not the purpose of this paper to discuss at any length[2] the merits of this type but a brief summary of its advantages seems desirable.

Compared with the regular gravity section of stone or cyclopean masonry we note that the latter is usually designed in such a way that the resultant pressure on the base acts at or near the downstream edge of its middle third. Here the water pressure is turned downward by the weight of the masonry alone, and it is readily seen that an increase in head on such a dam will cause the resultant to pass outside the middle third, producing tension at the upper toe and finally overturning the structure if it does not fail in some other way before this occurs. In the hollow type the inclined slab causes the water pressure to be directed downward at all times, and the

* *Proceedings*, Am. Soc. C. E., Feb. 1913, p. 117.

[1] *Eng. News.*, Vol. 68, 1912, p. 446.

[2] *Eng. News*, Nov. and Dec., 1911.

resultant pressure can be made to cut the base at any desired point by varying the design.

The facility with which the base pressure may be reduced in intensity by spreading the base, and made uniform over the base by correct proportioning is one of the marked advantages of this type of dam. In some cases, where the river bed is a hardpan or cemented gravel, overlying impermeable strata, the dam may be built directly on this material, because of this fact, and no deep foundations need be used. Extreme caution should be exercised in using this form of construction, however, and in general the buttresses should rest on rock or its equivalent, and the cut-off wall should extend to impermeable strata below all possible underflow.

The danger of ice thrust is also eliminated, as an ice jam would be forced up the inclined slab and its weight distributed over the structure, or, if the water were high enough, would be forced over the top of the dam.

Cost.— While the hollow dam will, in general, cost less than a masonry structure of the gravity type, and while there are many places where the easy control of base pressure in the former makes it available because the cost of the latter would be prohibitive, no fixed cost relation can be given. Reinforced concrete work requires steel and lumber, the cost of which may, in some localities, be excessive, making a gravity dam more economical.

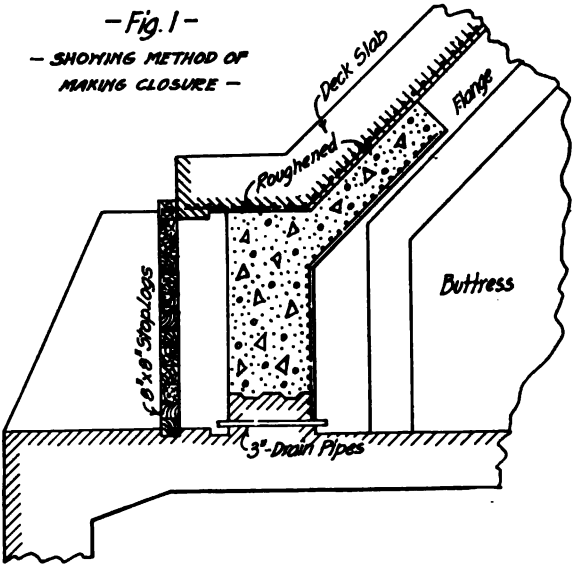
Life.— No actual failures have been recorded, but the oldest dam has been in service only 10 years. Cases have occurred in which the foundation has washed out under the dam, which has arched over the opening and remained practically intact. These serve to emphasize very forcibly the necessity of having the cut-off wall extend to a sufficient depth. It should also be remembered that the strength of the structure depends primarily on the imbedded steel, which must therefore be fully protected from rust. This can be done only by proper allowance for temperature cracks, by the use of expansion joints, and by using a concrete which will be essentially watertight. Mr. Edward Wegman has discussed this feature very fully[8] and it is at once apparent that the utmost care should be exercised in proportioning, mixing and placing the concrete of

[8] *Eng. News*, Vol. 68, 1912, p. 446.

the deck. Allowance must therefore be made in the design to facilitate this work, and careful supervision is of paramount importance.

Spillway.— Several types have been developed, depending on the head and on the foundation material. On ledge rock, a spillway section with a complete or part rollway is used when the fall exceeds 10 ft. or thereabouts, depending on the quality of the rock surface and its ability to withstand the force of the falling water. On soft material, either a water cushion must be formed for low heads, possibly by slightly extending the base of the dam and placing a small barrier dam at its downstream edge, or a complete rollway, with or without an apron to prevent scour, must be used.

Construction.— The usual method is similar to that employed in the construction of masonry dams, but the required cofferdam is usually far less costly and of a more temporary character. The



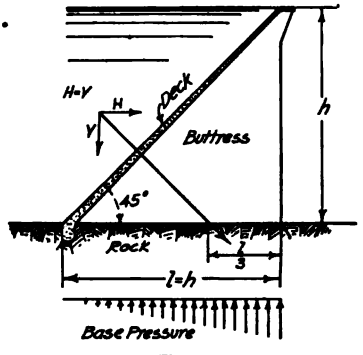
foundation and lower sections of the bulkhead are first constructed, and the entire flow of the stream is allowed to pass through this partially completed section while the upper parts of the buttress and slab are being erected and the remaining portions of the dam completed. The final closure is usually made as shown

in Fig. 1, without employing any expensive cofferdam. This method is patented. The procedure in the erection, field joints, and forms will be discussed further on.

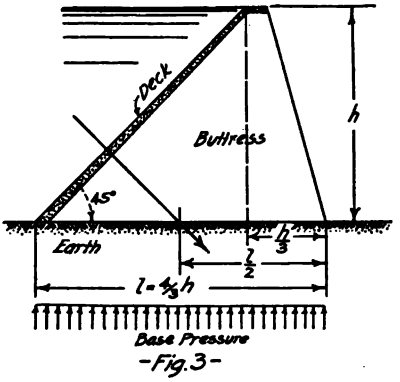
General Design.

Slope of Deck and Shape of Buttress.— The deck slope is generally made 45°. The reason for this becomes clear by reference to Figs. 2 and 3. Fig. 2 represents a dam on a rock foundation where the resultant base pressure may be allowed to take the triangular form, i.e., the resultant may cut the base at or inside the middle third. This result must be obtained at the least cost. Neglecting the weight of the dam itself, and drawing the buttress with a vertical downstream face, which will evidently be the minimum practical form, it may be easily shown that a 45° slope for the deck just satisfies this condition. A steeper slope would result in a little saving in the deck but would require an addition to the buttress on the downstream side to keep the resultant within the required limit. A greater slope would result in an increased slab and buttress. The relation, base equals height, therefore represents the economical proportions for this type of dam on a rock foundation.

On some foundations it is evident that it will be advantageous to



-Fig.2-



-Fig.3-

have a practically uniform distribution of loading over the base. A brief consideration will show that this can best be obtained by applying an additional downstream section to the buttress, as shown

in Fig. 3, giving a total bottom width equal to $1\frac{1}{3}$ h. The uniform distribution of pressure could have been obtained, it is true, by decreasing the slope of the deck, but this would result in increasing the vertical component of the resultant water pressure and thus also the intensity of the base pressure, a condition not desired. It is therefore clear that the slope of the deck may be made 45° for all conditions and, in softer material, the buttress may be given a downstream slope of between 0.25 and 0.33 of its height; this will bring the center of pressure about the center of the base, when the weight of the dam is considered in conjunction with the vertical component of the water pressure.

The top width of the buttress may be zero, but will generally be made 3 or 4 ft., to provide additional strength for ice thrust, where such is liable to occur, or to carry a walk across the top of the dam to facilitate inspection, etc. Where no ice is expected the walk may be carried on brackets, as shown in Fig. 2.

Buttress Thickness.— The buttress may have a tapering section, varying from a minimum thickness of 12 in. at the top to dimensions determined by the allowable pressure on the concrete, and shear at the different depths. The tapered section is, however, not so advantageous from the constructor's standpoint as a vertical section, increasing by offsets at intervals of 10 or 12 ft.; this plan offers a support for the bottom of the forms for each "lift." The minimum section should therefore be of 12-in. thickness for not over 10 or 12 ft., and should be increased in thickness 2 in. for each additional 10 or 12 ft. of depth, or as required by the working stresses in the concrete. A 1.3.6 concrete is commonly used for the buttresses, the allowable compression on which may be taken at 300 lb. and direct shear at 75 lb. per sq. inch.

Struts.— These should be introduced at suitable points to brace the buttresses transversely. They should be placed a distance apart not over 15 times the thickness of the buttress and, to facilitate construction, should be placed at the levels where the offsets in the buttress occur. Their least dimension should not be less than $^1/_{15}$ the distance between buttresses, and they should be reinforced to act as columns and carry their own weight as beams.

Spacing of Buttresses.— This will usually be between 14 and 18

ft., depending on the height and unit costs. As the distance, center to center of the buttresses is decreased, the span of the deck slab is decreased, and hence a saving in its cost results. More buttresses will be required, however. It is therefore clear that there must be some spacing which results in the greatest economy.

This economical spacing may be determined by the formula:

$$l^2 = \frac{370 + 17.5\,h}{\sqrt{\frac{h}{2}}}$$

in which h represents the average head and l is the spacing of buttresses. This formula can be readily derived by finding the volume of concrete and steel, and the area of form work in the deck, buttresses and foundations in terms of h and l; applying to the same certain assumed unit prices and taking the first derivative of the total cost with respect to l. By equating this result to zero the value of l as above is found to satisfy the conditions of minimum cost under the units assumed. The unit prices will, of course, vary with local conditions but it will be found upon analysis of the formula that even under considerable variation in the unit prices the value of l will not change much. The prices assumed in this case include only the items affected by a variation in the buttress spacing, and were as follows:

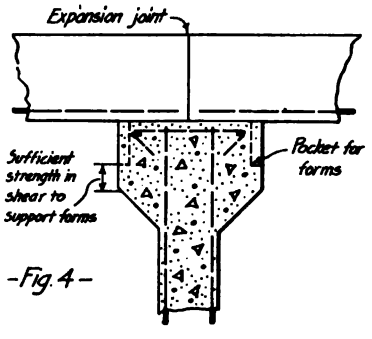
Concrete in deck	14.0c. per cu. ft.
" " buttress and foundation	12.0 " " "
Steel in deck and foundation	1.9c. per lb.
" " buttress	2.0 " "
Forms (labor only)	10.0c. per sq. ft.

Substituting in the above equation the average value of h, which is 18 ft. for the design hereafter considered, gives the economical spacing of 15 ft., which has been used.

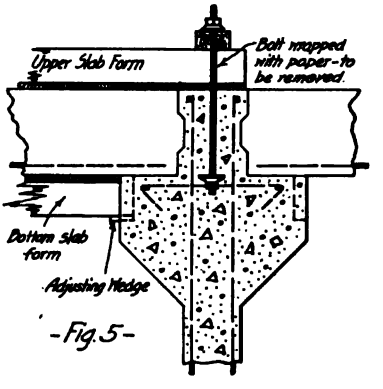
Buttress Flanges.— Two methods are available for making the connection between buttresses and adjoining slabs. A continuous slab over the buttress would not be used, as expansion joints will be placed here to prevent cracks from forming in the deck. This point has already been discussed, and is of vital importance.

The type of joint shown in Fig. 4 is evidently very simple and would doubtless be preferred by some engineers, as it would be less costly than that shown in Fig. 5. The latter possesses some important advantages, however. Thus, the joints for expansion are

doubled. The projecting portion between the slabs is cast with the buttress and not only furnishes lateral stability to the buttress from the slabs, but also furnishes a support for the top slab form



-Fig. 4-



-Fig. 5-

and acts as a bulkhead when the slab is cast, thus saving this troublesome detail. It enables a bolt to be set in, as shown, to hold the outside form for the slab, said bolt being removed with the forms without leaving any hole through the slab. The slab span is also shortened by the greater projection of the flanges, and its cost is reduced, while the large mass of concrete thus concentrated in the flanges adds greatly to the stability of the structure.

The design of these flanges is largely a matter of judgment. It has been shown by tests of simply supported beams, with straight horizontal rods, that the length of support (overhang of the bracket or flange) must be greater than that required simply to keep the bearing pressure within reasonable limits, or the beam will fail in bond at the ends. It may also be shown by a simple computation involving the increase of concrete and steel in the projection, and the corresponding saving in the concrete and steel of the slab, that for economy the average projection may generally be made about equal to the average slab thickness.

If we attack the problem in another manner, that is, by computing the thickness required for shear, we shall generally arrive at about the same figures. Thus recent tests [4] have shown that a plain concrete bracket will take an ultimate shear of about 100 lb. per

[4] *Concrete-Cement Age*, Feb. 1913, p. 68.

sq. in. on the section where it joins the buttress. The same tests prove conclusively that the hook form of reinforcement, such as is shown in the design herewith given, is the most efficient form and that brackets so reinforced may take as high as 400 lb. per sq. in. ultimate shear. It would therefore appear to be reasonable to compute the flange for, say, 40 to 60 lb. per sq. in. The slope of the bracket outward from the buttress certainly should not be made greater than 45° and the minimum thickness of the flange at the outer edge must be sufficient to give a bearing with the required strength in shear for the ends of the beams which support the form for the bottom of the deck slab, as shown in Fig. 5. All these points must therefore receive due consideration in designing this important detail.

The flange may, of course, be decreased in size toward the top of the buttress, and this would be done in very high dams. In dams of moderate height, however, it will be seen that economy in forms makes it desirable to keep the projection the same throughout, and simply cut down the depth or thickness. This can be easily done, using the same forms throughout, if they are properly designed. In the design hereafter considered, the same projection is used throughout.

The size of reinforcing rods is largely a matter of judgment. Tests show that the best form is the horizontal hook. Two vertical rods are run down the flanges and the smaller transverse bars are hooked over them. These hooks and rods serve the double purpose of reinforcing the projection as a cantilever, and also in aiding to take up any tension in the direction of the slab, due to the friction between the slab and the bracket, which may occur if the slab contracts.

Deck.— The thickness of the deck slab should not be less than 10 in. at the top, to allow space for properly placing and tamping the concrete of the deck. This concrete should be a rich, dense mixture, usually 1.2.4, and should be mixed wet to insure the filling of all voids and the thorough coating and protection of the rods.

It will generally be found that if the thickness is assumed as 10 in. at the top, and is computed at the bottom of the buttress, that a straight line between these points will give a sufficient thickness

at any other depth. A change in deck slope at each lift may be made without any difficulty, so that economy will result if the thickness is computed at these points and the slope made uniform between them.

Slab Formulas.— The following formulas may be easily deduced for the thickness of the slab and the required amount of steel for bending at any depth.

Let w = weight of any liquid in lb. per cu. ft.

x = depth of liquid on slab in ft.

l = span of slab in ft.

Then the bending moment in the slab = $wxl^2 \div 8$ for a non-continuous slab, and with water at 62.5 lb. per cu. ft. $M = 7.898xl^2$. But from formula for reinforced slabs, $M = Cbd^2$, and we have

$$d = \sqrt{\frac{7.818xl^2}{Cb}} \quad \text{.....(a)}$$

For a 1.2.4 concrete, with n = 15, $f_c = 600$ and $f_s = 14{,}000$ lb. per sq. in., $C = 8.50$ ft. lb. and $b = 12$ in, for a slab. Hence in non-continuous beams, d in inches = $0.277\, l \sqrt{x}$ .....(b)

Also from the formula $A_s = \frac{M}{f_s jd}$ we have $A_s = \frac{7.818xl^2}{f_s jd}$ per ft. width of slab, where A_s is in square inches. Now the spacing of the bars in inches to obtain this area is $S = 12 \times$ *area of one bar* $\div A_s$. Hence the spacing at any depth is:

$$S = \frac{12 \times \textit{area of one bar} \times f_s jd}{7.818xl^2} = K\frac{d}{x} \quad \text{.....(c)}$$

where K is a constant when the size of the bars to use has been decided on, the other quantities being known.

The shear, as a measure of diagonal tension, may generally be taken at a somewhat higher figure than customary as the slab will be so thick in proportion to its span at the depth where the shear is high that considerable arching will occur. Taking this figure at 60 lb. per sq. in. we find

$$\text{Reaction per inch of slab} = \frac{62.5\,lx}{2 \times 12} = \tfrac{7}{8} \times 60d = \tfrac{7}{8} \times 60 \times 0.277\, l\sqrt{x}$$

giving $x = 31$ ft.; that is, when the height of dam exceeds 31 ft. the shear in the slab near the buttresses becomes the limiting factor.

As the depth increases a slab of arched section may be used, giving a sufficient thickness of concrete at the ends that the shear will not exceed 60 lb. per sq. in., and the required steel is introduced for bending. An increase in the strength of slab to resist diagonal tension could, of course, be obtained by using stirrups. This would permit a shear up to 120 lb. but it would be very difficult, if not impossible, to place the stirrups properly in constructing the slab, hence this method is not used.

Foundation.—On firm ledge rock no spread footing may be necessary, but on softer rock a stepped-out footing can be used. By varying the width of footing the unit pressure may be made almost uniform, even with a buttress of the shape shown in Fig. 2. In some cases, the bases of the buttresses are stepped out, the thickness and amount of steel being computed, with due allowance to shear and bending, on the assumption that the spread acts as a cantilever, and the remaining space between buttresses covered with a reinforced floor which is computed as a continuous beam supported by the cantilever footings. Weep holes are placed at intervals throughout the base to prevent upward water pressure on it.

The angle of the resultant pressure on the base should also be investigated, and proper precautions taken to prevent sliding of the dam.

Spillway.— The length, elevation, and depth of probable flood flow having been decided on, it remains to take care of this flow so that no damage will result to the structure. The following formula has been used in designing the curve for the upper part of the spillway.[5]

$$x^2 = 2.3 \times H \times y \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (d)$$

Where x = the offset in feet.

y = the distance below crest in feet.

H = depth of flood flow in feet.

It is believed that this equation gives a spillway curve such that the overflowing water will adhere to the spillway surface and no vacuum effect will be possible. In order to guard against this, however, vent pipes are introduced in each bay, as shown in the accompanying drawing.

No satisfactory method seems to have been developed for design-

[5] *Eng. Rec.*, Oct. 24, 1908, p. 461.

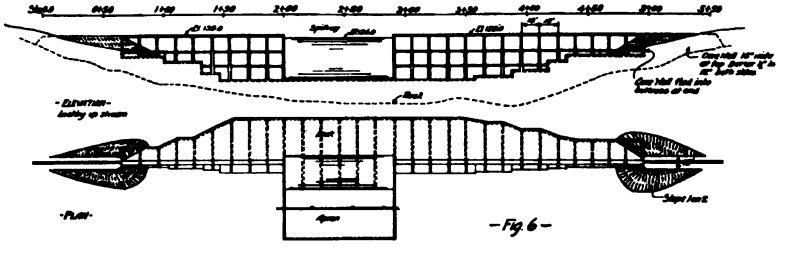
ing the lower curve of the ogee section. In the design given this curve has been made the reverse of the top curve, which seems to be a safe procedure.

The design of the curved spillway slab is essentially a matter of judgment, the thickness and reinforcing depending on the expected flood flow and the possibility of logs, ice, etc., being carried over the dam.

COMPUTATIONS.

General Conditions.— The general layout and profile are shown in Fig. 6. The conditions for the design are as follows:

In order to illustrate the method followed in such a design, the river bed will be assumed as hardpan and the conditions such that



—Fig. 6—

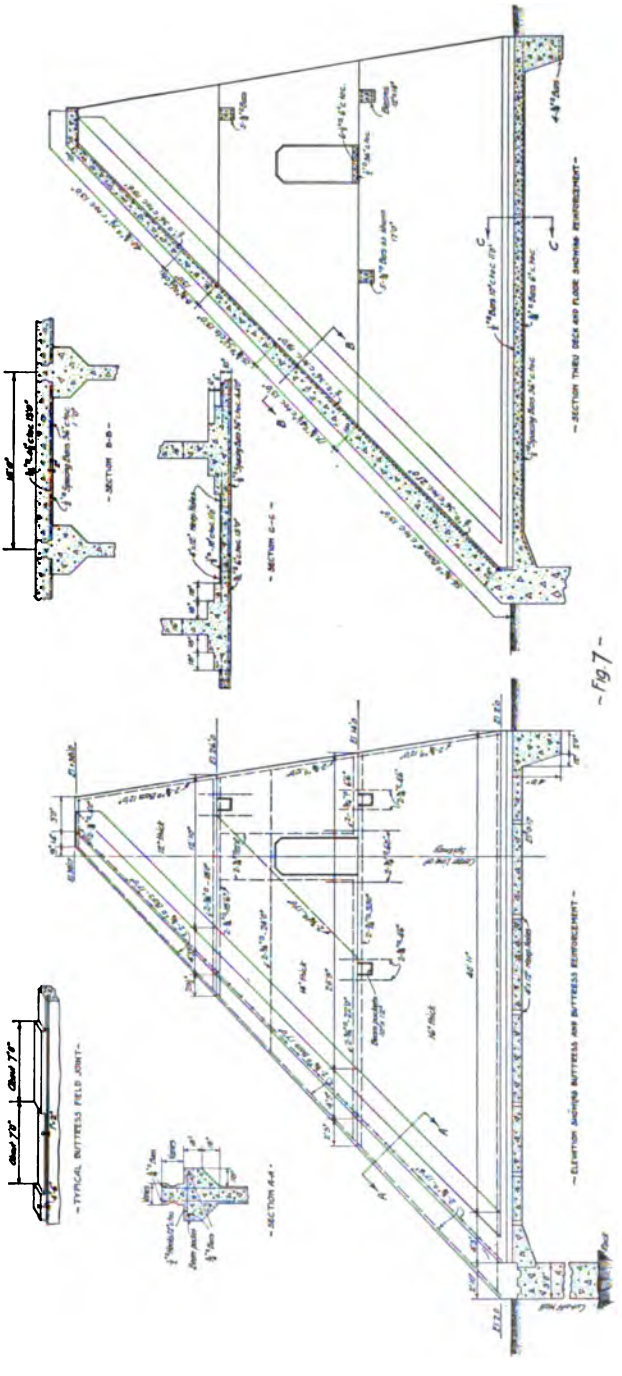
the dam may be built on a spread foundation resting directly on the river bottom, provided the foundation pressure is made uniform and at an intensity not to exceed 2 tons per sq. ft. A full rollway section for the spillway, with downstream apron to prevent scour, is also desirable.

Elevation of crest of spillway will be taken as + 36 ft.; maximum flood height 37.5 ft.; and crest of dam + 39 ft., making an allowance for waves, etc., of 1.5 ft. Dam will be designed for a head of water equal to the full height of dam and the spillway to pass a 3-ft. flood.

Unit stresses in lb. per sq. in.

	Deck and Apron	Buttress	Footing
Mixture	1.2.4	1.3.6	1.3.6
Concrete in compression	600 (bending)	300 (direct)	500 (bending)
Concrete in shear (direct)	—	75	75
Concrete in shear (diag. tension)	60	—	40
Steel in tension	14 000	—	14,000

The section at greatest depth only will be designed. For other depths, a similar section is used, the floor system being stepped up, as shown in Fig. 6, with step-up walls designed to resist the lateral


- SECTION B-B -
- SECTION C-C -
- SECTION THRU DECK AND FLOOR SHOWING REINFORCEMENT -
- TYPICAL BUTTRESS FIELD JOINT -
- SECTION A-A -
- ELEVATION SHOWING BUTTRESS AND BUTTRESS REINFORCEMENT -

- fig 7 -

earth pressure, and provided with pipe drains to prevent the possibility of water pressure.

Buttresses.— Width of base will be made about 0.3 greater than height (37 ft.) or 48 ft. Top width for walk, 3 ft. Built in three lifts of 12 ft., and thickness of 12, 14, and 16 in., as shown on Fig. 7. Reinforcing bars will be placed as shown to tie the buttress together, as it has been found from experience that they are necessary to prevent cracks. Struts will be used as shown, and door openings left in each buttress, with connecting slab, forming a passageway entirely through the dam.

Buttress flanges will be made with an overhang of 18 in. or about equal to the depth of slab. This is a little over the economical amount but inasmuch as it will be found later that the minimum thickness of the outer edge of the overhang must be about 16 in. in order to support the forms, this figure will be used, as it gives a proper proportioning. As a check, the shear should be computed at the center of the flange, using about 50 lb. per sq. in. This will be found to check closely with the design given. The same forms will be used throughout, so the overhang will remain constant.

Slab.— Using a minimum of 10 in. at the top, the required thickness at elevations 2.0, 14.0, and 26.0 are computed by equation (b) and found to be 22, 19 and $14\frac{1}{2}$ in. respectively, allowing 2 in. for protection. At elevation 2.0, however, the depth is 37 ft.; hence the shear, as a measure of diagonal tension, will control. This may be taken at 60 lb. per sq. in., a high value, which is permissible because the slab is so deep in comparison to its span that arching will doubtless occur. Hence

$$d = \frac{62.5 \times 12.16 \times 37}{2 \times 12 \times 60 \times \frac{7}{8}} = 22 \text{ in.} + \text{protection} = 24 \text{ in.}$$

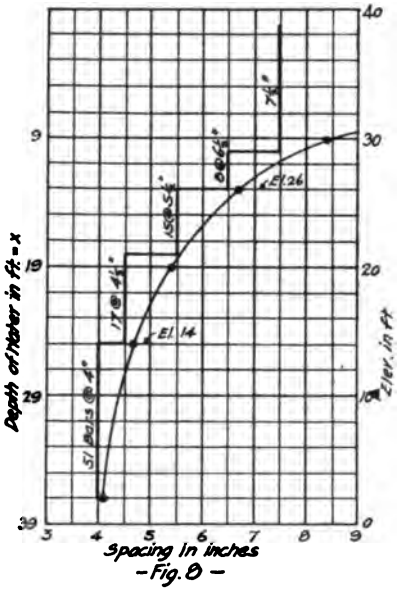
and the slab will be made 24 in. thick.

The steel may now be computed from equation (c) which reduces to $S = 6.95\, d \div x$ if we use $\frac{3}{4}$-in. square bars. These bars are used as they will give a reasonable spacing (4 in.) at the bottom of the slab and may be used throughout with very little waste. It is a poor plan to use bars of different sizes in the deck, as there is a possibility of the bars being placed incorrectly. It is also prefer-

able to make the change in spacing at the lift levels where the forms will be changed.

At el.	2	effective	depth = 22	in	s = 37	ft. and	S = 4.1	in.
" "	14	"	" = 17.0	"	= 25	"	= 4.7	"
" "	20	"	" = 14.75	"	= 19	"	= 5.4	"
" "	26	"	" = 12.5	"	= 13	"	= 6.7	"
" "	32	"	" = 12.25	"	= 7	"	= 12.0	"

Plotting these results we obtain the curve shown in Fig. 8, from which the spacing of the bars is taken as indicated.



– Fig. 8 –

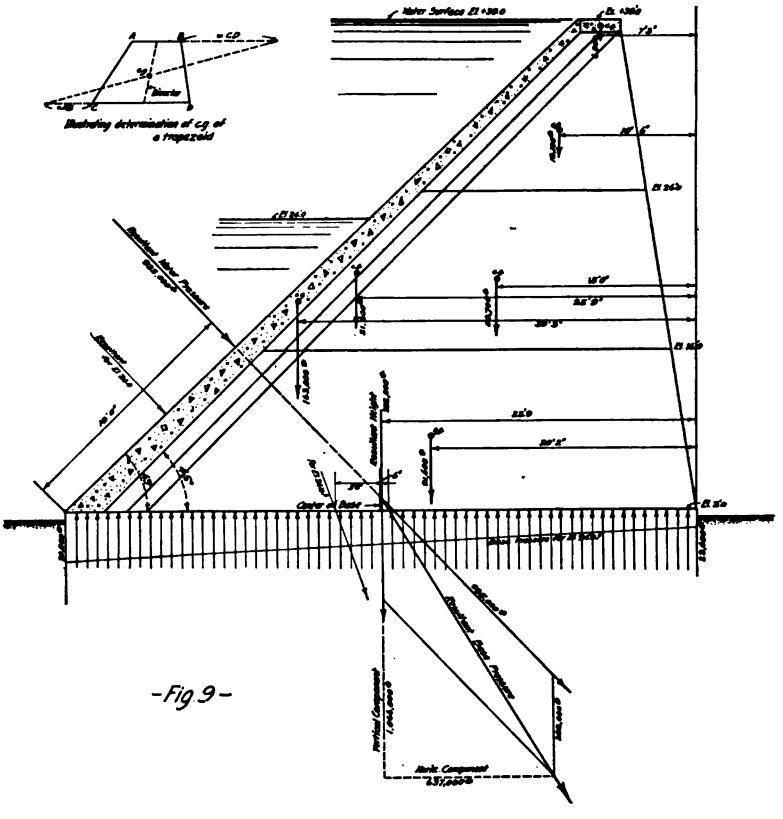
Spacing bars ½ in. square, 36 in. on centers, will be used throughout the slab to hold and secure the reinforcing bars at the proper spacing, and will be lapped 2 ft. into each "lift" of the slab to tie the sections together.

It now remains to check the buttress design for shear and compression, determine the foundation pressure and design the footings.

The horizontal water pressures may be found from the formula $wx^2 \div 2$, which amounts, divided by the area of the buttress section at elevations 26.0, 14.0, and 2.0, give 22, 44 and 61 lb. per sq. in. respectively, which stresses are within the allowable.

Foundation Pressure.— Fig. 9 shows the graphical construction

for determining the base pressure. The weights of the slab, flanges, and sections of the buttress are first computed, allowing 150 lb. per cu. ft. for the concrete. The center of gravity of each section is



-Fig 9-

then determined as shown, and the line of action of the entire weight of the dam is determined by taking moments about the toe. Thus:

	Weight.		Moment about Toe.
Walk	6,800 lb.	× 7.25 =	49,000
Top lift buttress	18,100 "	× 10.5 =	190,000
Middle lift buttress	50,700 "	× 15.0 =	760,000
Bottom lift buttress	91,600 "	× 20.17 =	1,840,000
Slab	163 200 "	× 30.25 =	4,950,000
Flanges	51,600 "	× 25.75 =	1,328,000
Total	382,000 "	Total moment =	9,117,000

Distance from lower toe to line of action = 9,117,000 ÷ 382,000 = 23.9 ft.

The resultant water pressure per bay, which acts one-third up the inclined slab and at right angles thereto, (note that the slope of the front face of slab is about 43°) is found to be

$$\frac{62.5 \times 37}{2} \times 54 \times 15 = 935{,}000 \text{ lb.}$$

Combining this with the total weight of dam, as shown, the resultant is found to cut the base 0.5 ft. downstream from the center. The total weight of dam plus $935{,}000 \times \cos 43°$ (or 684,000 lb., the vertical component of the water pressure) gives the total normal pressure on the base of 1,066,000 lb. Using the well known formula,[6]

$$p = \frac{P}{l}\left(1 \pm \frac{6b}{l}\right)$$

where p = pressure on base in lb. per lin. ft.

P = total vertical load in lb.

l = length of base in ft.

b = distance resultant pressure to center of base in ft.

we get an equivalent uniform load of 22,200 lb. per lin. ft. and p (max.) = 23,600 and p (min.) = 20,800 lb. per lin. foot.

As the width of buttress is 16 in. this represents a maximum compressive stress on the buttress of 23,600 ÷ (12 × 16) = 123 lb. per sq. in., which is entirely satisfactory. A similar computation for elevations 14.0 and 26.0 will also give results well within the limit of 300 lb. allowed.

The resulting pressure on the base with the water level at elevation 24.0 is also shown.

Footings.— A cross-section of the footing is shown in Fig. 7. It is designed as a simple cantilever footing having a width sufficient to transmit the load from the buttress to the soil at a reasonable unit foundation pressure. Thus, if we assume the width of cantilever as 10.5 ft. the load will be 2,250 lb. per sq. ft. The exact distribution of the foundation pressure is indeterminate and the unit pressure directly under the footing will probably be in excess of the above figure, but it is thought that this represents a safe

[6] See Baker's "Masonry Construction," p. 473.

design for the footing. The thickness of the cantilever next to the buttress will be controlled by shear, which may be taken at 50 lb. per sq. in., giving a required thickness of $2{,}250 \times 4.58 \div 12 \times \frac{7}{8} \times 50 = 19\frac{1}{2} + 2\frac{1}{2}$ in. protection = 22 in.

The bending moment would be

$$M = (2250 \times 4.58 \times 4.58) \div 2 = 23{,}600 \text{ ft. lb.}$$

From the formula $A_s = M \div f_s jd$; with $f_s = 14{,}000$, $f_c = 500$, $n = 15$, we have $j = 0.884$ and

$$A_s = \frac{M}{1030\,d} = \frac{23{,}600}{1030 \times 19\frac{1}{2}} = 1.17 \text{ sq. in. per ft.}$$

or $\frac{3}{4}$ in. square bars, 6 in. center to center, will be required.

The points where the raises in the footing may be made so that the shear may not exceed 50 lb. can be found by drawing a line from the edge of the buttress at the top of the footing to the center of steel at the edge of the cantilever. This gives a convenient raise of 6 in. with an offset of 18 inches.

The slab covering the space between the ends of the footings will be computed as a continuous beam with a span of $15 - 10.5 = 4.5$ ft. The maximum load that could come on this slab would occur on the assumption that the foundation load is uniformly distributed over the entire foundation. This assumption would give a load of $23{,}600 \div 15 = 1{,}570$ lb. per sq. ft., and the bending moment in the slab would be $M = (1570 \times 4\frac{1}{2} \times 4\frac{1}{2}) \div 12 = 2650$ ft. lb., requiring an area of steel $A_s = 2650 \div (1030 \times 8\frac{1}{2}) = 0.30$ sq. in. per ft., which can be obtained by using $\frac{1}{2}$-in. square bars 10 in. center to center.

Stability against Sliding.— The horizontal component of the water pressure will be $935{,}000 \times \sin 43^\circ = 637{,}000$ lb. This will be resisted by the friction of the whole structure on its base, plus the resistance of any projections that may be placed on the base for that purpose. Adding to the total weight already determined, 1,066,000 lb., the weight of the floor, which is 150,000 lb., we find that the coefficient of friction must be equal to $637{,}000 \div 1{,}216{,}000 = 0.52$. This is a rather high value, and if any doubt exists of the ability of the foundation material to give this resistance to sliding, the dam should be provided with base projections of sufficient size to

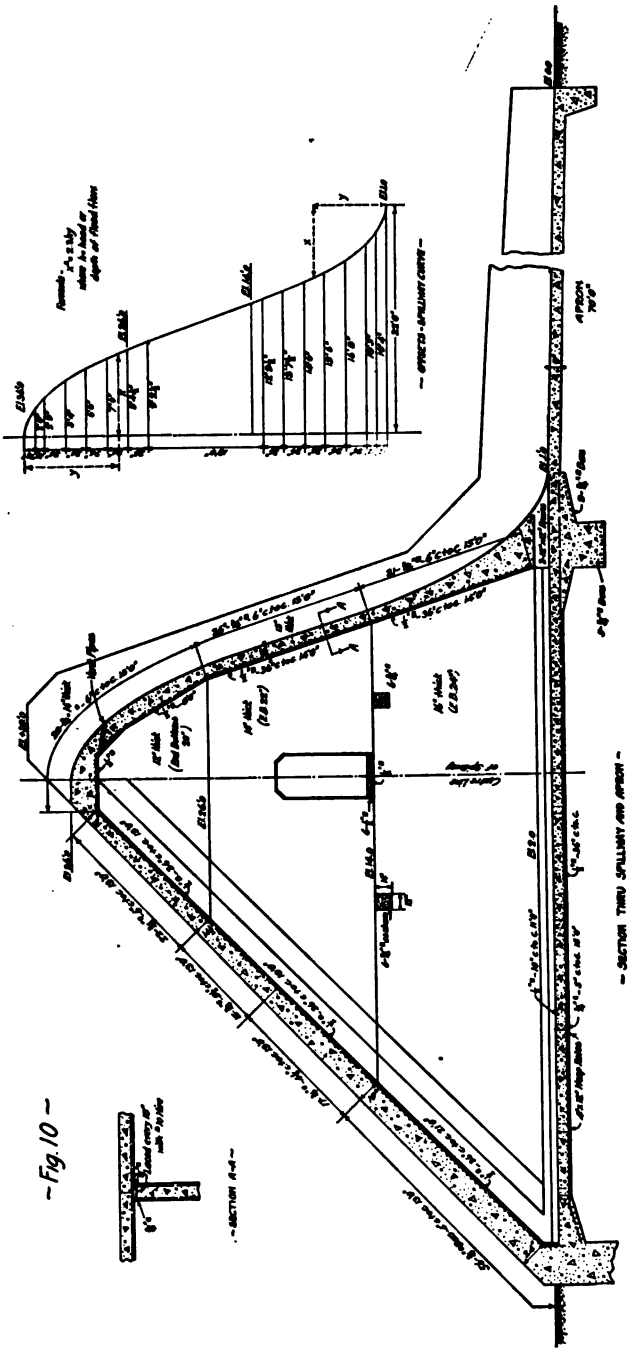


Fig. 10.

resist the unbalanced thrust. The 4-ft. cut-off wall, shown in Fig. 10 at the downstream toe, will aid in resisting sliding, but should not be counted on to do so as its function is simply to prevent possible backwash from undermining the floor.

Spillway.— The spillway design is given in Fig. 10. The formula used to compute the spillway curve has already been stated and it was also stated that the design of the rollway slab was largely a matter of judgment. The other features of the design are identical with those already discussed, and no further computations will be made.

Forms.

Wall forms will be built in panels, as shown, the area of the panel being determined by the fact that, even where derricks and cable-ways are available, conditions frequently arise that require the manhandling of forms; hence they must be within the lifting capacity of the number of men that can be conveniently grouped around them for that purpose. For this reason no form will exceed 800 lb. in weight.

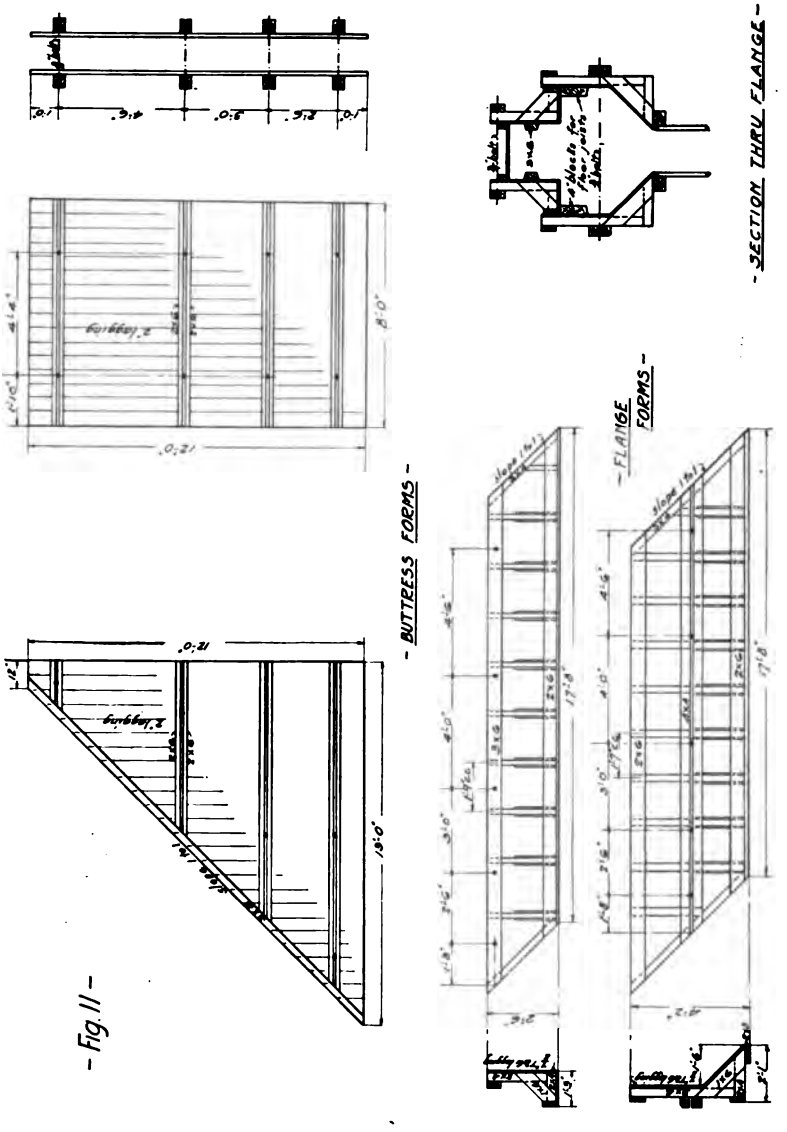
All forms will be designed to resist the loadings due to pressure of water in the concrete for the full heights of each lift.

Stresses used will be based upon the ultimate unit stresses recommended by the Association of Railway Superintendents[7] with a safety factor of three, which is ample for temporary work of this character.

Bolts will be introduced where necessary, note being made of the fact that the spacing of bolts depends not upon the tensile resistance of the steel itself but upon the crushing resistance of the wood under the washer of the bolt. Where bolts pass through the concrete they are surrounded by a substantial paper or tin tube which permits their removal after the concrete has set.

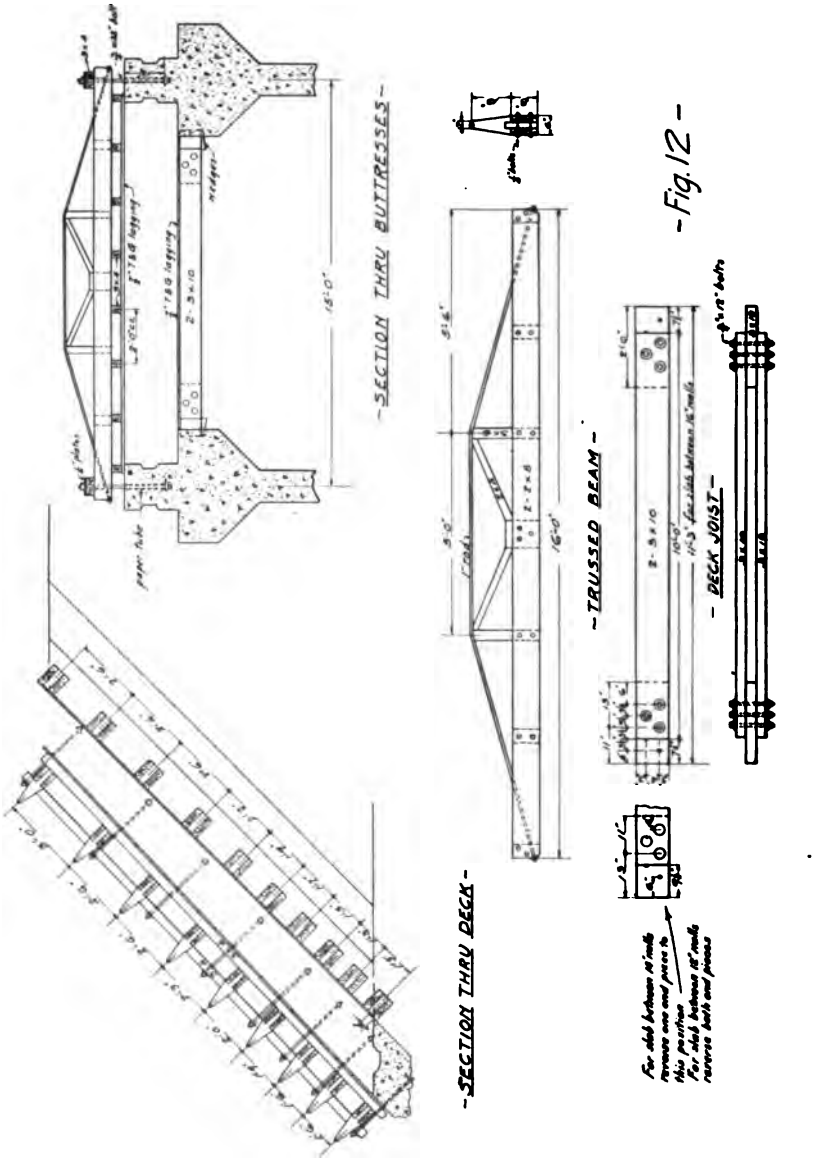
Joists for deck forms will be made up as shown, to facilitate removal of the centering. This arrangement also provides for lengthening out of joists, which is necessitated by the narrowing of the buttresses, by merely reversing the small end timber, at each lift.

[7] Cambria Handbook, pp. 362-3.



- Fig. 11 -

Forms for the top of the deck will have to resist the same unit pressures as those on the bottom, but the span is considerably greater. To avoid heavy and expensive timber, a light "strong back," or trussed beam, will be used. The wooden members of this



beam will have to be designed to resist bending as well as direct compression.

ECONOMICS OF MOTOR TRUCKING.—I.

BY CLINTON BRETTELL.*

The purpose of this article is to compare gasoline and electric motor trucks with those drawn by horses, as to speed, convenience, reliability, and cost of operation. No mention will be made of the field in which motor trucks compete with steam railroads, beyond noting the fact that the minimum distance above which railroads are able to haul cheaper than motor trucks is steadily being extended. Neither will attention be paid to those vehicles used exclusively for the transportation of persons.

There are several ways of making a cost comparison. One is to reduce all costs to a "per day" basis. This method is of little value, for while the motor truck costs more per day, it also does more work per day. Then there is the "cost per mile" basis. This is a little better, but also shows but one phase of the question, as no account is taken of the tonnage moved. The third method, and the best one, considered from all sides, is the "cost per ton-mile." This is the method which will be employed in practically all cases throughout this paper. Data on the subject of transportation costs are abundant, but so many methods of bookkeeping and computation are used that it is not safe to accept any of them off-hand. Before adopting them for comparisons they should be carefully analyzed.

Motor Trucking.

To be accurate, the cost of operation for motor trucks should include the following items:

I. *Fixed Charges.*— Based on an average number of working days. A figure of 300 working days per year is often used, and approximates quite closely the actual working days for the average case.

A. Driver's Wages.— About $20 per week is a fair charge for this item.

* M. E., Columbia, 1911. Truck Sales Department, Locomobile Company of America, Bridgeport, Conn., to whom the author is indebted for permission to reproduce many of the tables and diagrams in this article.

B. Garage.— If the truck is stored in a public garage, about $25 per month is charged. This includes washing, polishing, inspection, heat, light, power, etc. If the owner maintains his own garage, this figure may be somewhat lower. In that case the charge for storage, to compare with the above, would be made up as follows: (*a*) Interest on investment, including building, property and equipment. (*b*) Insurance and taxes on same. (If the building is rented, the above, i.e., interest on investment, insurance and taxes on building, and an additional charge for depreciation on building would all be included in one item, rent. (*c*) Depreciation on building and equipment, if owned by truck owner; on equipment only, if building is rented. (*d*) Wages of attendants, elevator men, washers and polishers, inspectors, superintendent or foreman. (*e*) Charges for heat, light and power. (*f*) Charges for maintenance of building and equipment.

C. Insurance.— Fire, liability, theft, property damage. These rates vary all over the country. As a rule they are unreasonably high. In most cases the same rates as for pleasure cars are applied to commercial vehicles, without taking account of the lessened liability with slow moving motor trucks. Insurance against fire and theft is generally at some percentage on a partial valuation, say, 2¼ percent. on 80 percent. valuation. Insurance against property damage depends on the horse-power of the truck and is arranged on a sliding scale basis, which is arbitrarily adopted without scientific basis. Liability is usually a flat sum, being greater the more hazardous the occupation. This item should also include taxes for licenses, etc.

D. Interest.— Opinion differs as to what rate of interest to use. One common method is to assume as a basis the rate offered by banks. Whatever the rate finally adopted, it is well to recognize that there is a regular depreciation in the amount of capital invested; so that while interest for the first year is chargeable on practically full value, for the second year it should be on less than full value, for the third year on still less, and so on. The easiest way of taking account of this is to use an average rate of interest, assuming full capital first year and entire dissipation of capital at the end of, say, the tenth year. The average rate will then be ½ the flat rate decided on, say, ½ of 5 percent. This method charges too little in-

terest for the first five years and too much for the last five, the one balancing the other in the final result.

II. *Variable or Mileage Charges.*—

A. Depreciation.—To account for the gradual wearing out of the truck, even with the best possible care and maintenance, a certain amount must be charged off each year, so that at the end of the truck's life there will be a fund sufficient to purchase a new truck, identical with the old one. There are various methods of fixing a rate of depreciation. If a truck receives ordinary care and attention in the matter of upkeep, etc., and is not abused in operation, it will last as much as 10 years before it is really worn out, and many will last longer. (*a*) One method of charging depreciation, then, is to write off one-tenth the original value of the truck each year. Opinion differs as to the life, but under present conditions it is not wise to figure on over 10 years. Naturally a truck which is run 25 miles a day should last longer than one operated 100 miles a day, with equal care and attention in both cases. (*b*) This suggests a second method of charging depreciation, i.e., on a mileage basis, figuring the life of a truck at 100,000 miles under average conditions. The latter method seems the more logical one to follow, since in fixing the rate for the former method it was necessary to consider, among other things, the daily mileage of the truck. Cost per mile is thus equal to total cost ÷ total mileage.

B. Tires.—The life of tires is subject to practically the same discussion as given in connection with depreciation. The method generally employed is as follows: The tire maker guarantees his tires for a certain mileage (provided that rated capacities of tires are not exceeded, and in some cases, that speeds are limited to certain specified values) usually around 8000 miles. In addition, the time element is involved, because tires, being made of rubber, deteriorate even when standing idle. The tire maker covers this phase of the situation by stipulating (in most cases) that the guaranteed mileage must be covered within a given time, usually 12 months, to validate the guarantee. Hence cost per mile = cost per set of tires ÷ guaranteed (or actual) mileage, as the case may be.

C. Repairs (Exclusive of Tires).—This includes labor and material (and profit if work is done in a public garage). It is gen-

erally figured on a yearly basis and then converted to a mileage rate, by determining the yearly mileage. For electric trucks, this item includes renewals of plates, electrolyte, etc.

D. Gasoline or Current.—Cost of current, motors, etc., and cost per kw.-hour. This cost is figured for a year and then reduced to a mileage basis. Cost of gasoline depends on the fuel consumption of the motor and the prevailing price of gasoline. It is best to figure this on a yearly basis and then reduce to a mileage basis.

The same discussion applies to oil.

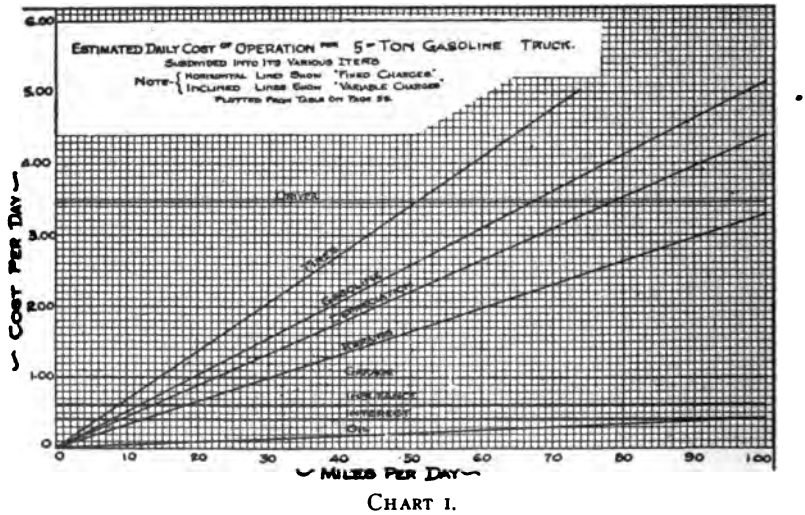


CHART I.

Summary.— The total of items under I gives total cost per day for fixed charges. Assuming a certain daily mileage, and multiplying the rates for the various items under II by this mileage, we get the daily cost for each item. Total of these gives total variable costs per day. Adding daily fixed charges and daily variable charges, we obtain total daily operating cost. Ton-miles per day is the product of the tonnage, by the distance this tonnage was carried. Dividing average cost per day by ton-miles per day, we obtain "Cost per Ton-Mile" which is the final result sought. As an example of the foregoing, see Table I, which shows costs for a 5-ton gasoline truck, figured for various daily mileages, and Chart I plotted from these figures.

TABLE I. ESTIMATED YEARLY COST OF OPERATING 5-TON GASOLINE TRUCK.

INVESTMENT	Chassis,.....$4800.00 Chassis, with Stake Body..... 5000.00								
Miles per day	20	25	30	35	40	45	50	60	70
Miles per annum	6000	7500	9000	10500	12000	13500	15000	18000	21000
FIXED CHARGES Cost per day									
Driver *3.466*	$1040.	$1040.	$1040.	$1040.	$1040.	$1040.	$1040.	$1040.	$1040.
Garage *1.000*	300.	300.	300.	300.	300.	300.	300.	300.	300.
Insurance ..... *.633*	190.	190.	190.	190.	190.	190.	190.	190.	190.
Interest ..... *.416*	125.	125.	125.	125.	125.	125.	125.	125.	125.
T'l Fixed Charges *5.515*	1655.	1655.	1655.	1655.	1655.	1655.	1655.	1655.	1655.
VARIABLE EXPENSES Cost per mile									
Depreciation ..... *.044*	267.	333.	400.	467.	534.	601.	668.	802.	934.
Tires ..... *.068*	405.	506.	607.	709.	810.	911.	1012.	1215.	1418.
Repairs ..... *.033*	200.	250.	300.	350.	400.	450.	500.	600.	700.
Gasoline ..... *.051*	308.	386.	463.	540.	617.	694.	771.	925.	1079.
Oil ..... *.004*	24.	30.	36.	42.	48.	54.	60.	72.	84.
Total Variable Ex. *.200*	1205.	1505.	1806.	2108.	2409.	2710.	3011.	3614.	4215.
Total cost per annum.....	2860.	3160.	3461.	3763.	4064.	4365.	4666.	5269.	5870.
" " " day	9.53	10.53	11.53	12.54	13.55	14.55	15.55	17.56	19.60
" " " mile	.476	.422	.384	.358	.339	.324	.311	.293	.280
" " " ton-mile ..	.190	.168	.154	.143	.136	.129	.124	.117	.112

NUMBER OF WORKING DAYS, 300.
FULL LOAD CARRIED HALF WAY.
DRIVER, $20. per week.
GARAGE, $25. per month.
INSURANCE, FIRE 2½% of $4,000; LIABILITY, $100.
INTEREST: The interest charge represents the average yearly interest at 5% on principal.

NOTE:— Mileage costs shown in Italics should not be used in figuring yearly costs under "Variable Expenses," as they are only carried out to three decimal places and are therefore only approximate.
The variable expenses shown under the various mileages were worked on yearly totals.

DEPRECIATION, (Less cost of tires). Life of truck figured at 100,000 miles.

TIRES, $540. per set for 8,000 miles guaranteed by tire manufacturer.

REPAIRS, $500. per annum for daily mileage of 50 miles, (or 15,000 miles per annum) — (exclusive of tires).

GASOLINE, 18c. per gallon, (3.5 miles per gallon).

OIL, 40c. per gallon, (100 miles per gallon).

NOTE: — The above yearly cost of tires does not take into account the tires on the truck when delivered. Accordingly $540. should be deducted in estimating tire cost for first year.

Horse Trucking.

Following out the same computation for horse-drawn trucks, the costs would be determined as follows:

I. *Fixed Charges.*—

A. Driver.—In case the driver's wages are paid by the week, it is best to figure this item on the basis of a year and then reduce it to a daily basis. For average figures at Chicago, see Table II.

TABLE II. COSTS INCIDENT TO HORSE TRANSPORTATION, CHICAGO.

Commodity	1871	1881	1891	1901	1906	1911	1912
Corn per Bu.	$ .39	$ .635	$ .59	$ .675	$ .46	$ .70	$ .90
Oats per Bu.	.33	.468	.334	.483	.358	.474	.40
	1903	1907	1908	1909	1910	1911	1912
Hay per ton	$15.00	$21.50	$14.00	$17.00	$21.00	$25.00	$20.00

Chicago Truck Drivers' Wages Per Week.

Type of wagon	1902	1904	1906	1909	1910	1912
Single wagon — one horse	$11.00	$11.25	$11.25	$11.50	$12.00	$13.50
Single wagon — two horses	12.75	13.00	13.00	13.50	14.00	15.50
Double wagon — two horses	13.75	14.00	14.00	14.50	15.00	16.50
Double wagon — three horses	15.50	15.75	15.75	16.00	17.00	18.50
Double wagon — four horses	16 50	17.00	17.00	18.00	18.00	19.50
Double wagon — six horses	18.50	19.00	19.00	20.00	20.50	21.50

Overtime (Year 1912), 30 cents per hour up to 8 P. M.

B. Stable.— If a truck owner keeps a stable for his equipment the following items should be included in the cost-account: (*a*) Feed, hay and straw, water and stable supplies. (*b*) Taxes, insurance, depreciation, interest; if the building is rented, rent includes all of these. (*c*) Light, heat, and power. (*d*) Wages of stablemen, helpers, etc.; salary of manager.

If he boards his horses, a flat figure covers all of the above items. Record of costs should be kept for a year and then reduced to a daily basis by using the average days in service per year.

D. Interest.—The same methods are applied as in connection with motor trucking. Interest on horses and equipment (harness, wagons, blankets, etc.).

E. Insurance.— No insurance is carried, as a rule.

F. Veterinary and Medicine.— Charges for a year are reduced to daily basis.

TABLE III. COST OF OPERATING HORSE WAGONS.
(On Basis of 5 Years' Operation. Loaded both Ways.)

2-HORSE WAGON.	
Price of open express-body wagon	$300.00
Price of two horses	400.00
Price of double set harness	75.00
Total cost of equipment	$775.00
Working days	300
Average miles per day	20
Load in pounds	8000

ITEMS	Per Year	Per Working Day	Per Mile	Per Ton-Mile	Per Cent.
WAGON EXPENSE					
Maintenance, grease, repairs, etc.	$ 125.00	.417	.0208	.0052	6.94
Depreciation 10%	30.00	.100	.0050	.0012	1.66
Rental value of space	25.00	.084	.0042	.0010	1.38
HORSE EXPENSE					
Depreciation 15%	60.00	.200	.0100	.0025	3.33
Ratio that die, 1 in 20	10.00	.033	.0016	.0004	.56
Feed and bedding	360.00	1.200	.0600	.0150	20.00
Care (Hostler)	100.00	.333	.0168	.0042	5.57
Veterinary	15.00	.050	.0026	.0007	.84
Medicine	10.00	.033	.0016	.0004	.56
Rental value space for horses	125.00	.417	.0208	.0052	6.94
Shoeing	50.00	.167	.0083	.0021	2.78
Water	10.00	.033	.0016	.0004	.56
Blankets	8.00	.026	.0014	.0004	.45
Deterioration to bldg. caused by horses	16.00	.053	.0027	.0007	.89
Rental value of space for storing feed	12.00	.040	.0020	.0005	.66
HARNESS EXPENSE					
Depreciation	7.50	.025	.0012	.0003	.41
Maintenance and repairs	10.00	.033	.0016	.0004	.56
Rental value of space	5.00	.017	.0008	.0002	.28
GENERAL					
Interest on investment	46.50	.155	.0077	.0019	2.58
Driver's wages	750.00	2.500	.1250	.0313	41.66
Stable supplies	15.00	.050	.0025	.0006	.83
Removing manure	10.00	.033	.0016	.0004	.56
	$1800.00	$5.999	.2998	.0750	100%

3-HORSE WAGON.	
Price of open wagon	$ 375.00
Price of three horses	750.00
Price of harness	100.00
Total cost of equipment	$1225.00
Working days	300
Average miles per day	18
Load in pounds	12000

Per Year	Per Working Day	Per Mile	Per Ton-Mile	Per Cent.
$ 125.00	.417	.0232	.0039	5.20
37.50	.125	.0007	.0011	1.56
30.00	.100	.0056	.0009	1.25
112.00	.374	.0208	.0035	4.66
10.00	.033	.0018	.0003	.42
550.00	1.834	.1019	.0169	22.91
150.00	.500	.0278	.0046	6.25
20.00	.066	.0036	.0006	.83
15.00	.050	.0028	.0004	.63
150.00	.500	.0278	.0046	6.25
75.00	.250	.0139	.0023	3.13
15.00	.050	.0028	.0004	.63
12.00	.040	.0022	.0004	.50
25.00	.084	.0046	.0007	1.05
15.00	.050	.0028	.0005	.63
12.00	.040	.0022	.0004	.50
20.00	.066	.0036	.0006	.83
8.00	.027	.0015	.0003	.33
73.50	.245	.0136	.0024	3.06
900.00	3.000	.1666	.0278	37.50
25.00	.084	.0046	.0007	1.05
20.00	.066	.0036	.0006	.83
$2400.00	$8.001	.4380	.0739	100%

II. *Variable Charges.*—

A. Depreciation.— Distinctly a mileage charge, as horses are worn out much quicker by working long hours, and constantly, than by giving them plenty of rest. Under average conditions, horses are unfit for heavy trucking after more than a few years' service. Life of wagons, while somewhat longer, depends on the amount of service; also on nature of service and care as to upkeep. Yearly mileage under average conditions is based on average number of working days, and an average daily mileage (not over 18 miles for light work, considerably less for heavy work). The original cost must thus be divided over the total mileage for the working life of the horse. Cost of wagon is distributed in same way. This gives cost per mile.

B. Repairs.— Repairs on harness and wagons, painting, etc., are figured for a year and then reduced to a mileage basis by applying the total yearly mileage. For any given daily mileage, find total mileage cost per day. Then sum of fixed and variable charges gives total cost per day. Dividing by ton-miles per day gives the final result, cost per ton-mile. The curves shown in Chart II give quite accurately the ton-mile costs for various capacities of trucks, gasoline, electric and horse-drawn, figured for various mileages. Table III shows another method of keeping the cost records for two-horse and three-horse wagons. The final result is cost per ton-mile.

Comparative Economies.

The costs of horse transportation were calculated as follows: A one-horse truck with driver can be hired for $4 per day. Its maximum daily mileage would be 22 miles and its maximum capacity 1 ton. Hence, ton-miles per day (full load half way) = $\frac{1}{2} \times 22 \times 1 = 11$.; and cost per ton-mile = $4.00 ÷ 11 = $0.364.

Similarly:

Two-horse truck with driver	$6.00 per day
Maximum daily mileage	20 miles
Maximum capacity	3 tons
Maximum ton-miles per day = $\frac{1}{2} \times 20 \times 3$ =	30
Cost per ton-mile = $6.00 ÷ 30 =	$0.20

Three-horse truck with driver	$8.00 per day
Maximum daily mileage	18 miles
Maximum capacity	5 tons
Maximum ton-miles per day = $\frac{1}{2} \times 18 \times 5$ =	45
Cost per ton-mile = $8.00 ÷ 45 =	$0.178

TABLE IV. COST OF OPERATING 1, 3, AND 5-TON GASOLINE TRUCK.*

Average Expense of Operating Commercial Cars, Compiled fom Records of Trucks in Service.

FIXED EXPENSES.	OPERATING EXPENSES.	15 miles per day; 4500 miles per year.	20 miles per day; 6000 miles per year.	30 miles per day; 9000 miles per year.	40 miles per day; 12000 miles per year.	50 miles per day; 15000 miles per year.	60 miles per day; 18000 miles per year.	70 miles per day; 21000 miles per year.
ONE-TON TRUCK								
Dep. on $2000@ 20% for 5 years $1.3030	Gasoline@15c.; 12 miles to gal.; .0125 per mile	.1875	.2500	.3750	.5000	.6250	.7500	.8750
Interest@6% .... .4000	Oil@30c.; 125 miles to gal.; .0024 per mile	.0360	.0480	.0720	.0960	.1200	.1440	.1680
Insurance ..... .1600	Grease and Supplies; .002 per mile....	.0300	.0400	.0600	.0800	.1000	.1200	.1400
Garage ..... .8000	Parts, renewals & painting; .0125 per mile	.1875	.2500	.3750	.5000	.6250	.7500	.8750
Total per day..$2.6630	Tires; .0111 per mile	.1665	.2220	.3330	.4440	.5550	.6660	.7770
	Driver, $2.50 per day	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
	Fixed Expenses	2.6630	2.6630	2.6630	2.6630	2.6630	2.6630	2.6630
	Total per day	5.7205	5.9730	6.3780	6.7830	7.1880	7.5930	7.9980
	Total per mile	3813	.2986	.2126	.1695	.1437	.1265	.1142
	Total per ton-mile	.3813	.2986	.2126	.1695	.1437	.1265	.1142
THREE-TON TRUCK								
Dep. on $3500@ 20% for 5 years $2.3333	Gasoline@15c.; 6½ miles to gal.; .0232 per mile	.3480	.4640	.6960	.9280	1.1600	1.3920	1.6240
Interest@6% .... .7000	Oil@30c.; 75 miles to gal.; 0040 per mile	.0600	.0800	.1200	.1600	.2000	.2400	.2800
Insurance ..... .2800	Grease and Supplies; .002 per mile....	.0300	.0400	.0600	.0800	.1000	.1200	.1400
Garage ..... .8000	Parts, renewals & painting; .0022 per mile	.3330	.4440	.6660	.8880	1.1100	1.3320	1.5540
Total per day..$4.1133	Tires; .0370 per mile	.5550	.7400	1.1100	1.4800	1.8500	2.2200	2.5900
	Driver, $2.50 per day	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
	Fixed Expenses	4.1133	4.1133	4.1133	4.1133	4.1133	4.1133	4.1133
	Total per day	7.9393	8.3813	9.2653	10.1493	11.0333	11.6103	12.8213
	Total per mile	.5292	.4140	.3088	.2572	.2206	.1935	.1831
	Total per ton-mile	.1764	.1380	.1029	.0857	.0735	.0645	.0610
FIVE-TON TRUCK								
Dep. on $4500@ 20% for 5 years $3.0000	Gasoline@15c.; 4 miles to gal.; .0375 per mile	.5625	.7500	1.1250	1.5000	1.8750	2.2500	2.6250
Interest@6% .... .9000	Oil@30c.; 40 miles to gal.; .0075 per mile	.1125	.1500	.2250	.3000	.3750	.4500	.5250
Insurance ..... .3600	Grease and Supplies; .002 per mile	.0300	.0400	.0600	.0800	.1000	.1200	.1400
Garage ..... .8000	Parts, renewals & painting; .0292 per mile	.4380	.5840	.8760	1.1680	1.4600	1.7520	2.0440
Total per day..$5.0600	Tires; .0583 per mile	.8745	1.1660	1.7490	2.3320	2.9150	3.4980	4.0810
	Driver; $2.50 per day	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
	Fixed expenses	5.0600	5.0600	5.0600	5.0600	5.0600	5.0600	5.0600
	Total per day	9.5775	10.2500	11.5950	12.9400	14.2850	15.6300	16.9750
	Total per mile	.6385	.5125	.3865	.3235	.2857	.2605	.2425
	Total per ton-mile	.1277	.1025	.0773	.0647	.0571	.0521	.0485

NOTE — Load carried full distance. For figures relating to intermediate, and longer distances, refer to the original paper. Costs per ton-mile plotted on Charts II and IV are for load carried half-distance; hence they are double those shown in this table.

* *The Commercial Car Journal*, Feb. 15, 1912.

TABLE V. COST OF OPERATING ELECTRIC VEHICLES.

(As published in February, 1912, by the Commonwealth Edison Co. of Chicago.)

ITEM.	1,000-Pound Wagon			2,000-Pound Wagon			2-Ton Truck			5-Ton Truck		
	Mileage Per Annum—10,500			Mileage Per Annum—10,140			Mileage Per Annum—9,390			Mileage Per Annum—7,200		
	Per Annum.	Per Day.	Per Mile.	Per Annum.	Per Day.	Per Mile.	Per Annum.	Per Day.	Per Mile.	Per Annum.	Per Day.	Per Mile.
Fixed Charges—												
Amortization	$220.00	$0.7333	$0.0210	$265.00	$0.8833	$0.0262	$340.00	$1.1333	$0.0362	$450.00	$1.5000	$0.0625
Interest	66.00	.2200	.0063	79.00	.2633	.0078	102.00	.3400	.0109	135.00	.4500	.0188
Fire insurance	22.00	.0733	.0021	26.50	.0883	.0026	34.00	.1133	.0036	45.00	.1500	.0062
Liability insurance	100.00	.3333	.2095	100.00	.3333	.0008	100.00	.3333	.0106	100.00	.3330	.0139
Total	$408.00	$1.360	$0.0389	$470.50	$1.568	$0.0464	$576.00	$1.920	$0.0613	$730.00	$2.433	$0.1014
Renewal Charges—												
Batteries	$187.00	$0.6233	$0.0178	$221.00	$0.7367	$0.0218	$289.00	$0.9633	$0.0308	$425.00	$1.4167	$0.0590
Tires	145.60	.4853	.0138	216.30	.7210	.0214	286.60	.9553	.0305	618.80	2.0627	.0859
Chains	25.20	.0840	.0024	32.30	.1077	.0032	37.90	.1263	.0040	58.10	.1936	.0081
Gears and sprockets	46.00	.1534	.0044	54.00	.1800	.0053	59.05	.1964	.0063	79.40	.2646	.0110
Bearings	22.65	.0755	.0022	25.55	.0851	.0025	30.35	.1011	.0032	43.15	.1439	.0060
All other parts	30.00	.1000	.0029	35.00	.1167	.0034	40.00	.1333	.0043	50.00	.1667	.0069
Total	$456.45	$1.522	$0.0435	$584.15	$1.947	$0.0576	$742.90	$2.476	$0.0791	$1,274.45	$4.248	$0.1769
Garage Charges—												
Electric power	$122.35	$0.4078	$0.0116	$152.10	$0.5070	$0.0150	$218.80	$0.7293	$0.0232	$330.50	$1.1016	$0.0459
Rent, light and heat	88.00	.2934	.0084	109.05	.3635	.0107	136.15	.4537	.0145	164.05	.5469	.0228
Garage labor	232.00	.7733	.0221	232.00	.7733	.0229	232.00	.7733	.0247	232.00	.7733	.0322
Total	$442.35	$1.475	$0.0421	$493.15	$1.644	$0.0486	$586.95	$1.956	$0.0624	$726.55	$2.422	$0.1009
Driver	750.00	2.500	.0715	750.00	2.500	.0738	750.00	2.500	.0798	750.00	2.500	.1042
Grand total	$2.056.80	$6.857	$0.1960	$2.297.80	$7.659	$0.2264	$2,655.85	$8.852	$0.2826	$3,481.00	$11.603	$0.4834

NOTE — 300 working days per year. For intermediate capacities, see original article in *Power Wagon*, Feb. 1912.

These are the extreme points for the three curves. For lower mileages, the costs will be higher. The daily mileages given are much higher than would be obtained under average operating conditions. Hence, in most cases, the costs would be found further up on the curves.

The figures from which curves in Chart II were plotted, for gaso-

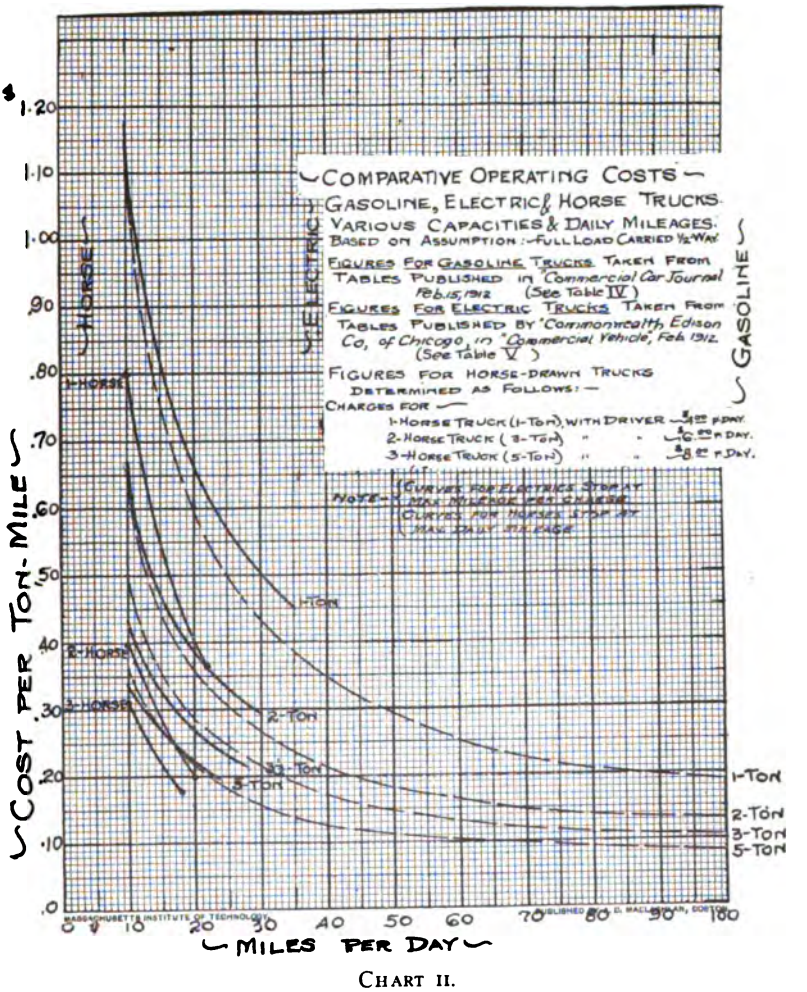


CHART II.

line trucks, are from figures given in a table (See Table IV) published in *Commercial Car Journal*, Feb. 15, 1912, and are averages

taken over a number of years, from records of trucks in actual service. They are based on the assumption that full load is carried *half way*.

The figures for electric trucks of from 1 to 5 tons capacity, (see Table V) were taken from a table published in Feb. 1912, by the Commonwealth Edison Company, of Chicago, a company operating a large force of electrics and supplying current to many others. Both these tables are thus from reliable sources.

In Chart III is given another set of curves showing: (1) Horse-haulage costs collected by the National Association of Automobile Manufacturers, from professional truckmen. (2) Probable daily

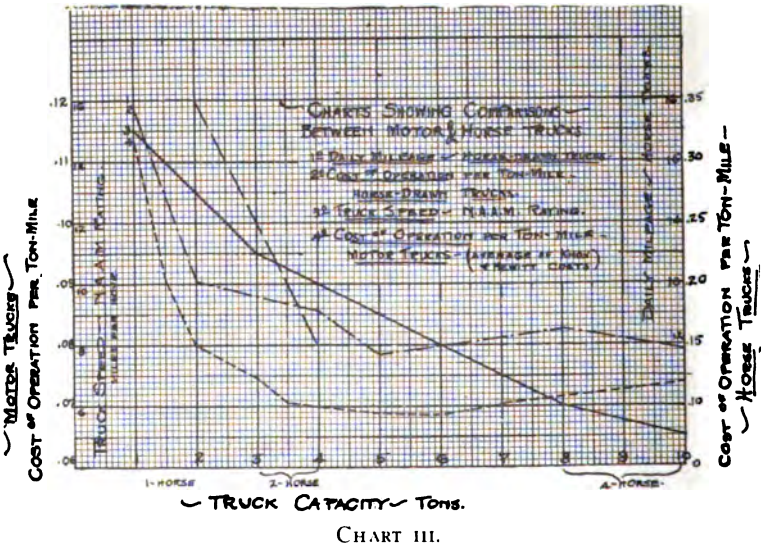


Chart III.

mileages for horse-trucks of various capacities. These are the results of actual practice. (3) Motor-truck speeds recommended by N. A. A. M. for trucks of various capacities. These speeds have been determined after considering all sides of the question, so that depreciation will not be too rapid, due to excessive speeds. (4) The costs shown in this curve for the operation of gasoline trucks of various capacities were plotted from figures published by the Knox and the Hewitt automobile companies. Part of the figures are averages of the two, the remainder being either Knox or Hewitt costs alone.

In Chart II, truck capacities up to 5 tons were shown. In Chart IV additional curves are shown for capacities from 6 to 10 tons. The same rates of increase were maintained in figuring the unit costs in these trucks of larger capacity, the results being checked by estimating the various items, such as tires, gasoline, etc., for the various capacities. In addition, calculations were made, assuming average conditions as to running speeds and working hours, to determine what daily mileages trucks of these various capacities would accomplish under ordinary conditions. Results were compared with figures submitted by the N. A. A. M., and were found to check quite well. A curve was plotted from these values, between daily mileages and truck capacity, on the same sheet with the other curves. This curve cuts the cost curves, thereby marking out the working part of these curves for average conditions. The cost curves approach one another as capacity is increased; increase of daily costs begins to catch up to increase in daily ton-miles, so that it becomes less and less of an advantage to increase from one capacity to the next. This is true even when the mileages per day are kept constant. But in actual practice, mileages decrease with increase of capacity so that the cost per ton-mile is checked in its fall, and in changing from 7- to 10-ton capacity there is practically no decrease in cost of hauling per ton-mile.

Referring again to Chart II, we find that for low mileages, up to about 18 miles per day, the three-horse truck is the most economical means of transporting goods. This then is the field of usefulness of the horse-drawn vehicle, i.e., where traffic, loading, unloading or other conditions are such that the conveyance is forced to remain idle a considerable portion of the day, with a correspondingly low daily mileage.

Thus it seems that the only argument that can be urged against the use of motor trucks in some classes of work is that the truck, owing to loading or unloading conditions, or both, may of necessity remain idle a large portion of the day and would therefore be uneconomical. Realizing the truth of this argument, the truck manufacturer is designing loading and unloading devices, by the use of which standing time is reduced to a minimum, and the motor truck is thus able to cope successfully with the horse, even in this short-

haul work. To reduce loading time, several means are resorted to, depending on the nature of the product to be transported. For building materials, coal, etc., cranes, scoops and other mechanical loading devices are employed with great success. For general mer-

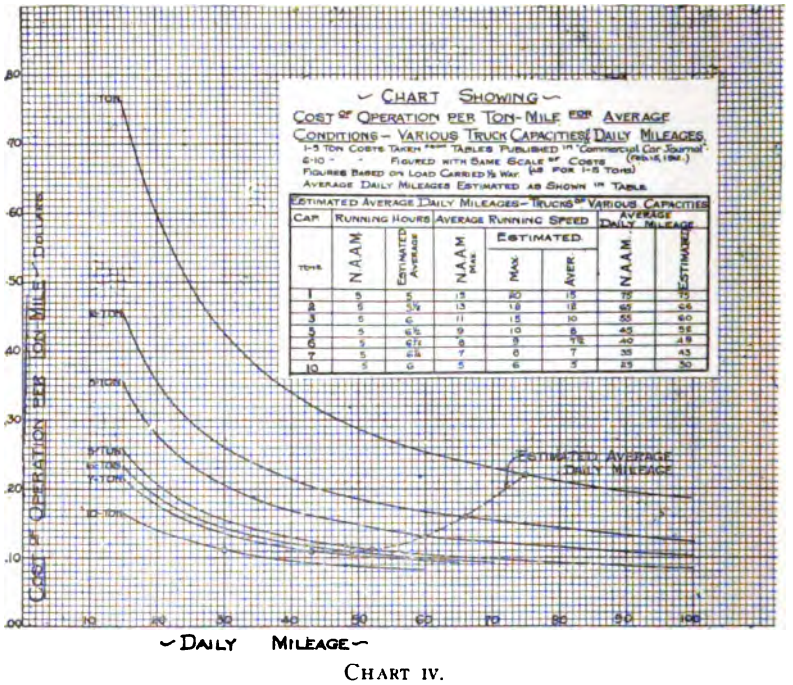


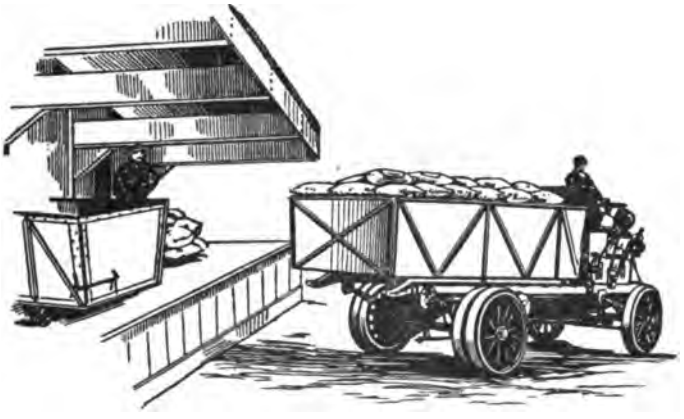
CHART SHOWING
COST OF OPERATION PER TON-MILE FOR AVERAGE
CONDITIONS – VARIOUS TRUCK CAPACITIES & DAILY MILEAGES
1-5 TON COSTS TAKEN FROM TABLES PUBLISHED IN "Commercial Car Journal" (Feb. 15, 1911.)
6-10 " " FIGURED WITH SAME SCALE OF COSTS (1/2 FOR 1-5 TONS)
FIGURES BASED ON LOAD CARRIED ½ WAY
AVERAGE DAILY MILEAGES ESTIMATED AS SHOWN IN TABLE
ESTIMATED AVERAGE DAILY MILEAGES – TRUCKS OF VARIOUS CAPACITIES
CAP. | RUNNING HOURS | AVERAGE RUNNING SPEED | AVERAGE DAILY MILEAGE
TONS | N.A.A.M. | ESTIMATED AVERAGE | N.A.A.M. RULE | ESTIMATED MAX | ESTIMATED AVER | N.A.A.M. | ESTIMATED
1 | 9 | 5 | 15 | 20 | 15 | 75 | 75
2 | 9 | 5½ | 13 | 18 | 12 | 65 | 66
3 | 9 | 6 | 11 | 15 | 10 | 55 | 60
5 | 9 | 6½ | 9 | 10 | 8 | 45 | 52
6 | 9 | 6¾ | 8 | 9 | 7½ | 40 | 49
7 | 9 | 6¾ | 8 | 8 | 7 | 35 | 43
10 | 9 | 6 | 5 | 6 | 5 | 25 | 30
COST OF OPERATION PER TON MILE – DOLLARS
.80
.70
.60
.50
.40
.30
.20
.10
.00
10 TON
8 TON
5 TON
3 TON
2 TON
1½ TON
1 TON
ESTIMATED AVERAGE DAILY MILEAGE
10 20 30 40 50 60 70 80 90 100
DAILY MILEAGE

CHART IV.

chandise, bodies made up of several units are used. For unloading, the bodies are made to dump either by power or by hand. Where removable units are employed, these are removed by cranes or trolleys.

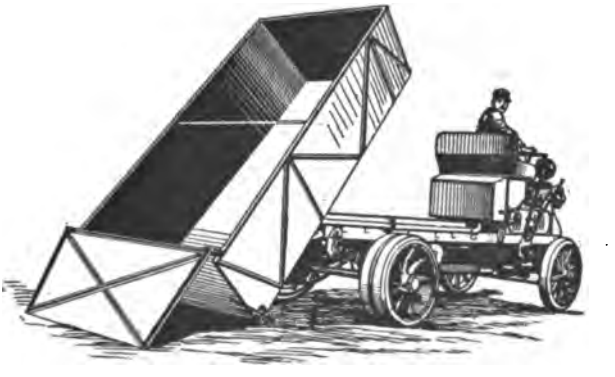
One company has brought out an arrangement which combines both the dumping and removable-body features. By means of several such bodies, the truck is enabled to keep in motion a large portion of the day, stopping only long enough to slide off an empty body and pick up a full one, the time required for the entire operation not exceeding five minutes. Loading and unloading can then be carried on as leisurely as the nature of the product or the rate at which it is delivered to shipping room may demand, without in any

way delaying the truck. If the material can be unloaded by dumping, this can be easily accomplished and in considerably less than five minutes. The operating time of the truck can thus be increased



Truck having deposited empty body and taken on loaded body under power from engine, departs on new trip. Total time required 3 minutes.

from less than half the working day to over three-quarters, with corresponding gain in economy. It is also possible to have several different types of bodies for one chassis, thus economizing in first cost.



Body is dumped and recovered by power of engine controlled by man on seat with small lever at side. Total time required to dump, 1 minute.

As an example of the economy introduced by motor trucks in transportation connected with engineering enterprises may be mentioned the case of the Bridgeport Hydraulic Co., engaged in the con-

struction of a large dam 7 miles outside of Bridgeport, Conn. Horse-drawn trucks were first considered as a means of transporting the materials to the dam, but on investigation it was found that in order to employ horses, the roads would have to be made over and, in one place, a hill cut down, with corresponding expense. In addition, the estimates on the cost of hauling showed about $0.35 per ton-mile, (1 team and driver, 2-ton load, 1 trip of 7 miles each way per day) as compared with $0.14 per ton-mile by motor trucks (4 trips per day @ $0.89 per ton; 5 tons per trip of 7 miles). Naturally motor trucks were selected and the wisdom of the selection is manifest when the actual figures after over six months' operation show the cost to average about $0.10 per ton-mile, or $0.04 cheaper than the estimate. These trucks have never faltered in spite of the severe road conditions encountered. They have since been equipped with power mechanism for rolling onto the body a pipe 48 in. diameter × 13 ft. long, weighing five tons. Four trips per day are made to the dam, one pipe being carried each time, or four pipes per day moved. To do this same work, four teams of six horses each, with additional horses to assist on the hills would be required. A trailer has been designed to carry an additional pipe on each trip and will be used as soon as road conditions permit. In addition to the economy gained, it might be added that the condition of the roads travelled by only one motor truck with broad tires, making four trips per day, is far better than with four teams with narrow-tired wagons which cut into the road bed, especially in bad weather. This should stand as an example for contractors engaged in this kind of work.

Considerations other than Economy.

As a rule, the matter of economy is the only one considered in deciding on the relative merits of horse and motor transportation. As a matter of fact, this is only one of a number of factors that help to determine which system is, on the whole, the more desirable. To make a fair decision, we must consider and weigh each of the following: (1) Area in which business can be done; (2) Regularity of service; (3) Rush of business; (4) Quick delivery; (5) Advertisement.

1. *Increase of Business.*— The limit of 18 miles a day for a three-horse team is much greater than would be reached even under the most favorable conditions. Ordinarily 12 miles per day would be more nearly correct. This would raise the cost per ton-mile a corresponding amount. On the other hand, the motor truck is almost unlimited in its radius of action; 75 to 100 miles per day is as easy for the motor truck as it is impossible for the horse-drawn truck. Thus it is plain to how great an extent business is cramped by adhering to the old-fashioned horse and wagon. As an illustration, I would mention the case of a soda-water manufacturer, of Hartford, Conn., who realized the advantages to be gained by pushing out his business into widely separated territories. He replaced his horse equipment by a 5-ton gasoline truck and then introduced his product into towns previously considered as belonging to other manufacturers, simply because Hartford seemed so far removed. The company in Hartford found that it could load a truck, send it to some city 20 or 30 miles distant, make deliveries there during the day, meanwhile picking up empty cases, and be back at the factory before nightfall. Naturally, this would have been utterly impossible with horse equipment. This is only one of many instances, records of which find their way into the trade journals from time to time.

2. *Regularity of Service.*— Weather conditions have little or no effect upon the motor truck. In former years, whenever extremes of weather were experienced, either as blizzards in Winter, or excessive hot spells in Summer, the horse was an object of pity, and transportation and delivery systems were correspondingly crippled. With the advent of the motor truck, the only limit placed upon its performance is the endurance of the driver. This feature appeals to the contractor who has an important job which must be finished at a certain time. He cannot afford to take chances on such delays in obtaining his materials as are common with horse trucks. Likewise the merchant, whose business depends to a great extent on the regularity with which he is able to make deliveries, finds in the motor truck a friend of no mean ability.

3. *Rush of Business.*— It is evident that by working the motor truck overtime, rush of business can be handled without interfering with regular deliveries. By employing two shifts of men, the truck

can be kept going almost continuously, with only an occasional intermission for inspection and minor adjustments.

4. *Quick Delivery.*— Where quick delivery is of prime importance it will often be possible to secure business from the customers of a more conservative competitor who continues to use horse delivery. Quick delivery is imperative with the florist and the merchant who handles perishables; also to department stores, which often secure trade simply because people appreciate prompt and reliable delivery.

The large express companies were quick to realize the importance of the three factors: Reliability of service, ability to care for rush of business, and quick delivery. To-day the transition from horse to motor in this work is almost completed. The Adams Express Co. now operates 485 motor trucks, gasoline and electric, representing an investment of $1,000,000 and an additional $300,000 for garage, shops, etc. The American Express Co. now operates 352 power wagons, including 28 electric baggage trucks at the terminals in Boston. A total investment of $1,000,000 is represented, including garage, etc., the trucks alone being valued at over $800,000. The Wells-Fargo Co. has 42 trucks at present, and expects in the near future to increase this to 200. The United States Express has 53 in service. The Long Island operates 36. This makes a total of 968 among five companies. It might be added that all the big express companies have motors on order.

5. *Advertisement.*— This may be a very important factor in some cases and will eventually force many an unwilling merchant into line with his more progressive competitor in the installation of motor equipment. The public is very keen to appreciate and reward up-to-date methods.

(Note.— The second installment of this paper, to appear in the July issue, will comprise detailed comparative statements of the cost of trucking by horse and by motor power in a number of particular industries, such as brewers, professional truckers, and dealers in ice, brick, lumber, produce, etc.—Ed.)

TESTS OF FIREPROOF CONSTRUCTION FOR THE CITY OF NEW YORK.

BY HAROLD PERRINE.*

The existing Building Code of the City of New York defines a fireproof building to be one constructed with walls of brick, stone, Portland cement concrete, iron, or steel, in which no wood beams or lintels shall be placed, and in which the floors shall be constructed with wrought-iron or steel floor beams. Between the beams are set brick arches, hollow-tile arches, reinforced Portland cement concrete segmental arches, or slabs of various materials and types. If the structure is not over 12 stories or 150 ft. in height, inflammable flooring and trim are allowed, but if it exceeds this height, the floor surfaces are of stone, cement, rock asphalt, tiling, etc., or the sleepers and floors are of wood treated to render it fireproof. Outside window frames are of metal or metal-covered wood; inside sashes and trim are of treated wood, and all partitions are of fireproof material. Exposed metal is always encased by a protective coat.

The term "fireproof," as applied to this entire class of buildings, is often erroneous. Few present forms of construction are strictly fireproof; some, however, have more and greater "fire-resisting" qualities than others. It is the duty of certain authorities in each large community to determine what systems possess these qualities, and to how great an extent, in order to minimize the loss of life and property in case of fire. In the several Boroughs of the City of New York the regulation of these matters falls under the jurisdiction of the respective Building Bureaus, this regulation being effected by constant tests and inspection. The methods of conducting these tests will be described in this article.

Two main classes into which fire tests are divided are: (1) those conducted upon full-size construction; (2) those upon samples. These are subdivided again as follows:

* In charge of the Columbia Fire Testing Station. The photographs with this article were supplied through the courtesy of J. Boldtman, School of Mines, Columbia University.

Full-size tests:

1 Floor construction.
2 Partition construction.
3 Doors, windows, etc.

Sample tests:

4 Flooring materials.
5 Moving-picture booth construction.
6 Building materials, used as substitutes for brick, i.e., cast stone, etc.
7 Fireproofed wood.

Full-size tests are, in the main, conducted in structures designed and built for that express purpose. Sample tests, on the other hand, may be conducted in any laboratory equipped with common standard apparatus, gas furnaces, torches, pyrometers, etc.

The methods described in this article are, in every case, those prescribed by the Building Code, and employed at the Columbia Fire Testing Station, Greenpoint, Brooklyn, New York, and in the Materials Testing Laboratories of Columbia University.

Tests of Floor Construction.

The system to be tested forms the roof of the test house, which structure is essentially a cinder-concrete oven of permanent construction. Properly supported upon piers 2½ ft. from the ground is a grate composed of railroad rails and wire mesh, about 250 sq. ft. in area. The vertical distance from the grate to the roof is about 9½ ft. The floor system to be tested is supported by steel I-beams resting on the tops of the walls, spaced at distances suitable to the span or spans under test, and having a clear span themselves of about 14 ft. Ample draft openings and flues are provided to facilitate the control of the fire, their location being readily seen in Fig. 1,

The purpose of the test is to determine the effect of a continuous fire below the floor lasting four hours, at an average temperature of 1700° F., a temperature generally conceded to be that of a burning building, the floor carrying at the same time a distributed load of 150 lb. per sq. ft. At the end of the four hours the under side of the floor, while still red hot, is subjected to a 1⅛-in. stream

of cold water through a hose at short range, under a 60 lb. pressure, for 5 min.; the upper side of the floor is then flooded with water at low pressure, and afterwards the stream is applied at

FIG. 1. FLOOR TEST — DURING FIRE.

full pressure to the under side for 5 min. longer. Deflections of beams and floor are measured continuously during the test. On the following day, when the floor is cool, the load is increased to 600 lb. per sq. foot.

Several cords of dried mixed pine and hardwood, kindled with shavings and kerosene oil, is the fuel used, the frequency of firing depending on the recorded temperatures. Water pressures are controlled by an engine furnished through the courtesy of the fire department. Temperatures are read from a Siemens-Halske galvanometer, to which are attached three thermo-electric couples at the ends of insulated wire leads. These couples, protected by proper tubing, are inserted through the floor so that they extend about

FIG. 2. FLOOR TEST — APPLYING WATER.

6 in. below its lower surface. The leads will be noticed in Fig. 1. Deflections are read by Y level, from an elevated position, upon vertical rods placed at various points on the floor. Loading is effected by means of pig iron applied in segregated piles, to insure uniformity, and to eliminate arching.

To pass the above test successfully, no flame must penetrate the floor, no part of the load shall have fallen through, and the beams must have been protected from the effects of fire and water so as not to have been deflected more than 2½ inches. Fig. 2 illustrates

the method of applying water to the under side of a floor system. The stream is first directed over the grate itself, extinguishing the fire, and is then pointed upward and played upon the test covering, but in a manner so as not to act continuously in one spot. Fig. 4 shows the condition, after test, of a terra-cotta tile arch, or dome. The right-hand portion is in excellent condition. This was due

FIG. 3. FLOOR TEST — FINAL LOAD.

mainly to the fact that this section, before the fire, was coated with plaster, while the left-hand portion was not so protected. Projecting through the arch at three points may be noticed the ends of the tubes in which were inserted, from above, the thermo-couples for recording temperatures.

TESTS OF PARTITION CONSTRUCTION.

The structure in which partition walls are tested is 14½ ft. long, 9½ ft. wide and 9½ ft. high. The side walls form the only parts under test, each being 138 sq. ft. in area; the end walls and roof are of permanent cinder-concrete construction. This chamber is

supported by foundation walls upon which also rests a grate. Draft openings are provided below this grate, as well as suitable chimneys leading from the top of the house.

The partition, or shaft construction, is subjected to a continuous heat from a wood fire for at least one hour. An average temperature of at least 1700° F. is maintained during the second half-hour.

FIG. 4. THE DOME, AFTER TEST.

At the end of an hour's fire each wall is subjected to a stream of water on the inside, through a fire hose with a $1\frac{1}{8}$ in. nozzle, at 30-lb. pressure for a period of $2\frac{1}{2}$ minutes.

As in the previously mentioned test, the firing is done with dry cordwood. All things considered, this is probably the best and most satisfactory fuel to use in these two tests. Gas or oil may be used, and is employed in some plants, but the wood fire certainly duplicates more nearly the conditions present in an actual fire, and is much more easily obtainable. Hydrant pressure should be ample for this test, and an engine is never necessary.

The temperature of the oven is observed by a Siemens-Halske galvanometer, to which are attached three couples. One of these

is inserted through each partition, (Fig. 5) projecting about 6 in. into the fire; the third is suspended through the roof. Inward and outward deflections of the walls are measured with reference to a wire stretched horizontally, near and parallel to the middle of

FIG. 5. PARTITION TEST — DURING FIRE.

their respective faces. Heat conducted through the partition is observed by a thermometer, insulated from radiating heat by a wooden box, its bare mercury bulb being in actual contact with the outside of the partition. (See Fig. 5).

A test of this character is considered successful when neither fire, smoke nor water passes through any part of the wall, nor is it bulged or otherwise deformed to the extent of rendering it un-

FIG. 6. APPLYING WATER — PARTITION TEST.

safe. Fig. 7 shows the excellent condition of the inside of a 3-in. cinder-concrete block partition, after having passed the above test. Fig. 8 shows a typical failure of an insufficiently protected sheet-metal wall construction. Note the warping of the metal

caused by expansion and also the total absence of plaster on the major portion.

Tests of Windows, Doors, Etc.

Tests upon this class of construction, together with those upon various forms of roofing, while essential to their acceptance for use in fireproof buildings in New York City, are not conducted in

Fig. 7. Partition Test — Result Satisfactory.

exactly the same manner as are all the other tests described in this paper.

The Underwriters' Laboratories at Chicago maintain equipment for testing the fire-resistance of many forms of protection devices. Their work is under the supervision of the National Board of Fire Underwriters. Reports of tests of different articles conducted in these laboratories are submitted to a council which designates their classification. The articles are then labeled in accordance

with the findings of the council. The labels represent the quality of the material as a fire-protection and are a safeguard to the consumer.

FIG. 8. PARTITION TEST — RESULT FAILURE.

Owing to the rigid methods of inspection practiced by the Underwriters, a duplication would be superfluous and consequently the approval of this body often will insure the acceptance of the article in question by the New York Building Bureaus, within the limits of the code. Since this paper deals with tests falling immediately under the direction of the city authorities, tests of win-

FIG. 9. LABORATORY TEST OF FLOORING MATERIAL.

dows, doors, etc., will not be described. The requirements for a fireproof door are, however, quite similar to those for a partition wall.

FLOORING MATERIALS — SAMPLE TEST.

A composition flooring material to be used in a building of 150 ft. in height must be subjected to the following test. A sample of the material 12 in. square and of the thickness to be used in service is laid face down upon two cast-iron supports, 1 in. thick, which are lying across the opening of an 8-in. gas and air crucible furnace. Directly beneath the sample, and exposed to the flame from the furnace, is inserted a thermo-couple encased in a quartz or porcelain tube, and connected by leads to a pyrometer. Against

the center of the back of the sample is placed a mercury thermometer in actual contact, but protected by proper means from circulating air currents. The temperature of the furnace is raised gradually from that of the room to 1700° F. in 20 min. and then maintained at that point for 10 min. longer. At the expiration of that time the sample is removed from the furnace and a stream of cold water, at about 60-lb. pressure, is directed against its face for one minute.

To pass this test successfully, the flooring should not warp to a great extent, nor should it crack across, burn, or be softened to a depth of more than half its thickness.

Fig. 9 shows the apparatus used at Columbia University to conduct this test. A sample may be seen resting over the crucible, the thermometer for noting the conducted heat is placed above it, and the pyrometric outfit is in position for easy control of temperature.

Moving-Picture Booth Construction.

A partition wall which has satisfied the requirements of the full-size partition test, described above, is acceptable as an enclosure for moving-picture apparatus. Also, "any other material such as asbestos board used as a covering for the angle-iron framework . . . must be at least ¼ in. thick, and must comply with the following tests and requirements for fire resisting qualities." The test consists of essentially the same procedure as in the above described flooring test.

Building Material Used as Substitute for Bricks.

Material in the form of bricks, artificial stone, etc., before being used within the city limits, is subjected to a series of tests including transverse and compressive strength, absorption, freezing and fire.

The latter test is run upon two samples. These are placed in a cold gas furnace, in the form of an oven, the temperature then being raised to 1700° F. in one hour. One of the samples is then plunged, red hot, into cold water and results noted. The second sample is allowed to cool slowly in air at room temperature. The material should not disintegrate under this treatment.

Fireproofed Wood.

The above term is applied to flooring and interior trim which has been treated by chemical impregnation to render it fire-retardant. It is, in fact, inflammable, if subjected to a hot flame for a sufficient time. But, when properly prepared, it will burn slowly in contact with the fire, but, on removal, will not support combustion even to the extent of glowing for more than a few seconds.

Every 2000 ft. of this material is sampled. These specimens are inspected as follows, to prove their fire-resisting qualities. At present, three tests are conducted upon pieces cut from each of the above samples, viz.: (1) Timber test; (2) Crib test; (3) Shavings test.

Timber Test.— From each of the submitted samples is cut a piece $12 \times 1\frac{1}{2} \times \frac{3}{4}$ in. This piece is planed to exact size and meas-

Fig. 10. Laboratory Timber Test.

ured accurately to 0.01 in. Such samples are then subjected in pairs to a vigorous flame from a gas crucible furnace for 2 min., at a temperature of 1700° F. They are then taken from the fire and the duration of flame and glow noted. The samples are then sawn in two, and the area of the least cross section measured by planimeter. Specifications for acceptance require a flame and glow of not more than 15 and 20 sec. respectively, and a percentage un-

burned area of 45 for soft wood and 55 for hard wood. (Fig. 10).

Crib Test.— Cribs are built up in four tiers of sticks $\frac{1}{2} \times \frac{1}{2} \times 4$ in. upon a chemists' ring stand, and subjected to an 18-in. flame from a gas torch at an approximate temperature of 1200° F. Combus-

FIG. 11. LABORATORY CRIB TEST.

tion, as evidenced by flaming, must be supported not longer than 20 sec. nor as evidenced by glowing, for more than 30 sec. (Fig. 11).

Shavings Test.— Thin shavings, taken from each of the above samples, are placed, in a 2-in. layer, on the wire-mesh bottom of a tin pan 1 ft. in diameter. A common bunsen burner, giving a yellow flame, is placed beneath the mesh for 25 sec. The shavings must not be consumed in less than 5 min. nor must the flame reach higher than 6 in. (Fig. 12).

Each sample of timber, representing as it does 2000 ft. of lumber, must pass satisfactorily two of the above three tests.

Veneer Tests.— Most veneers are obviously much too thin to permit of the use of the timber test. A test in use in the Columbia Laboratories, designed to meet this difficulty, consists of placing a small quantity of " splinters " upon a red-hot plate, maintained

FIG. 12. LABORATORY TEST OF SHAVINGS.

at about 1000° F. for 1 min. (Fig. 13). To pass successfully, none of the splinters must flame in less than 40 sec. A crib test, similar to the regulation one is also conducted upon veneers.

RESUMÉ.

The above regulations for testing various forms of construction for fire resistance are based upon the observations and experience of many investigators. Prof. Ira H. Woolson, formerly of the Department of Civil Engineering, Columbia University, devised and perfected several of the above tests, and was one of the pioneers, in this country, in this type of inspection. Sources from which results may be obtained are now so numerous as to facilitate to a marked degree the arrival at proper conclusions. One fact is worthy of note in this regard: Reinforced stone concrete floor

systems are now accepted, without test, as are also concrete building blocks, provided, of course, that they meet other requirements as to strength, etc. This marks an advance in our knowledge of the behavior of stone concrete in service, and denotes a feeling of

FIG. 13. LABORATORY TEST OF SPLINTERS OF VENEER.

confidence that the floor fire-test as now conducted affords ample protection. In fact, the American Society for Testing Materials has adopted it as a standard.

The same cannot be said of the full-size partition test. It seems to be generally conceded that the duration of the application of fire is about one-half what it should be, to insure the rejection of walls which will afford insufficient protection. The society mentioned above, through its Committee on Fireproofing Materials, recommends a two-hour duration of fire.

There are several possible improvements in the methods of handling laboratory specimens. The tests on moving-picture booth and flooring materials prove quite satisfactory as a rule, giving definite and conclusive results. The reverse is true in regard to the oven test on substitutes for brick. To specify that the specimens must not disintegrate is rather indefinite. Complete absence of disintegration is almost impossible, considering the severity of the action of

fire and water, while interpretation of the specifications to their exact letter is difficult. A definite means of inspection should be provided; for example, some form of test to ascertain the deterioration in strength after treatment would be advisable.

In regard to fireproofed wood, several profitable changes might consistently be made. The timber and crib tests probably should be retained, with slight variations, but the test on shavings should be omitted. It is extremely difficult to obtain shavings exactly duplicating one another, and, finally, any slight variation of draft conditions, height of flame, etc., vitally effects the results.

MOSESITE.

BY F. A. CANFIELD.*

In the first published description of mosesite, printed nearly three years ago,† it was said that specimens of this mineral would doubtless be found, labeled under another name, in some mineral collections.

I desire to verify this prediction by announcing the discovery of the third specimen of this mineral. In February, 1908, I purchased a small specimen from the dealer who has distributed the finest specimens that have been found at Terlingua, Texas. It was labeled "Kleinite" and it was bought for kleinite, but it was apparently such a poor specimen that it was not examined carefully at that time. A recent test proved the mineral to be mosesite. The only resemblance it bears to kleinite is its color.

The specimen is 2 cm. × 2 cm. × 1 cm. and weighs a little more than 8 grams. Nine-tenths of the mass looks like a very friable, dark-brown limonite that has been derived from the decomposition of pyrite — cubical forms suggest pseudomorphs of that mineral. Lying upon the matrix is a crystalline coating of mosesite mixed with gypsum. The quantity of the latter mineral is sufficient to reduce the color to a pale lemon tint, but in places the color is of a rich canary yellow; other portions have a greenish tint suggestive of terlinguaite. The mosesite also forms veinlets in and through the brown matrix. The crystalline coating is so irregular that distinct planes are rare and but few triangular faces can be seen. But few signs of twinning were noticed. These features are so different from those of the type specimens that it is still too soon to decide what the habits of mosesite are. In the first type specimen, nearly all of the crystals are simple octahedrons widely scattered over crystals of calcite, with which there is no bond.

In the second type specimen, almost all of the crystals are spinel twins, so numerous that they are crowded together and form a

* Dover, N. J. E. M., Columbia, 1873.

† *Amer. Jour. Sci.*, Sept. 1910. Mosesite, a New Mercury Mineral from Terlingua, Texas.

coating 4 cm. × 6 cm. on the pinkish rock, which is so common in the specimens from Terlingua.

A microscopic examination revealed six well formed crystals. One is a simple, clean-cut octahedron, with smooth faces and a rich color. The other five crystals are cubo-octahedrons modified by trapezohedrons. The forms found were 111, 211, 411, 611, 100. The last four are new for this mineral. The faces of the octahedron are uneven, the other faces are brilliant. Those of 211 gave a rather wide range of angles, which were averaged; the other measurments were definite.

The largest crystal measures 1 mm. between the opposite faces of the cube. This is much the largest crystal that has been observed. On specimen No. 3, the mosesite is intimately associated with gypsum and montroydite.

Dover, N. J., January, 1913.

BOOK REVIEWS.

General and Industrial Inorganic Chemistry, by MOLINARI. Translation from the 3rd Italian edition, by ERNEST FEILMANN. P. Blakiston Son & Co., Philadelphia. 1912. Cloth; 6x9½ in.; xvi+704 pp.; 279 illus. Price $6.00.

We have works on inorganic chemistry in which the mention of industrial applications is illustrative and incidental. We have works in industrial chemistry which are mainly technical and descriptive. The present book is a distinct and most valuable variation from the usual arrangements. In it inorganic and industrial chemistry are combined, and are woven into a well-reasoned whole by the systematic employment of the laws and principles of the science. The wealth of information about industrial processes will awaken the student of pure chemistry to a vivid realization of the wonderful ramifications of the science in the industries. At the same time, the scientific treatment of industrial operations will be most instructive to the student of chemical engineering.

The theoretical matter is fairly well presented in Part I (125 pp.), but the principles, thus introduced, are not, as so often happens, promptly ignored. They are thereafter used at every point in explaining the descriptive matter. There is a wealth of historical and incidental information scattered, in smaller type, throughout the book. The localities from which substances are obtained, the forms in which they occur, the quantities available, the costs of raw material and of various methods of treating it, the market prices, and a hundred other factors which enter into the study of the subject from the industrial side are all discussed. The space is admirably distributed in accordance with the importance of the subject. For example, adequate space is given to sulphuric acid (35 pp.) and to ceramics and cement (27 pp.) Numerous illustrations show the principle types of machinery employed in each industry. The technical information is up to date, so far as that is possible in a general work dealing with a rapidly developing subject. The chemistry is accurate in substance and modern in form. The book will prove a mine of information to the teacher of chemistry, whether his field be in the secondary school or in the college or university, and will be not less interesting to the student of chemistry or engineering chemistry. A. S.

A Manual of Cement Testing, for the use of engineers and chemists in colleges and in the field. By W. A. RICHARDS, Instructor in the University of Chicago, and H. B. NORTH, Associate Professor of chemistry in Rutgers College. Cloth; 5x8 in.; x+137 pp. D. Van Nostrand Co., New York. 1912. $1.50 net.

We are at a loss to discover the necessity for a new book on this subject, covering, as it does, the same field so ably treated by W. P.

Taylor in his standard work, "Practical Cement Testing." The new publication, however, represents both a saving in space and cost over the latter. It is, in fact, simply "Practical Cement Testing" condensed, this work being mentioned as a reference at the end of every chapter except the chapter on chemical analysis, which subject is treated somewhat more fully than usual.

Several statements in the book appear to be either incorrect or misleading and it is certain that a number should be qualified. Leaving aside the erroneous statement in the preface of the name of one of the societies, which has published standard cement specifications, we might point out on page 1 that it is customary to specify that additions to cement to control setting, etc., shall not exceed 3 percent., by weight, of the calcined product. On page 6 we find "Limestone is a substance formed when clay has been deposited with calcareous matter." It is true that the limestone generally known as "cement rock" does contain clay but on the other hand ordinary limestone, and that used in the manufacture of some Portland cements, is practically pure calcium carbonate containing little or no clay.

We are inclined to question the statement that "In itself fineness is of little importance," although it is taken direct from Taylor. While it is doubtless true that no sieve is fine enough to determine the flour in a cement, and that the coarser particles are inert and practically possess little cementing quality, the same observation applies here as in the case of other tests, such as specific gravity, for example. Briefly stated it is this: A large amount of cement testing is simply routine work to determine whether or not the shipment in question is up to the standard of that particular brand. Under such conditions both of these tests are of value "in themselves" and for comparison with previous tests of the same cement.

The statement that "handling a cement after it commences to set . . . will weaken it and cause it to disintegrate," on page 23, is also in need of qualification. If carried to the extreme this may be true, and tests, although contradictory, seem to show it to be true in any case for natural cement, but it has been conclusively shown that a thoroughly regaged or retempered Portland cement mortar may ultimately prove stronger than the same mortar allowed to set undisturbed. What we must endeavor to obtain in cement testing, so that our results may be comparable and in uniformity with those of other investigators, is standard conditions for testing. In order to do this, it is obvious that the cement must not be handled after it has commenced to set, but in practical work concrete sets more slowly than cement, and, while it is not a good plan to make a practice of doing so, it may be used without injury when it has been mixed two hours or more.

On the whole, the book is useful for a brief course in cement testing, and the chapter on chemical analysis is clear, brief and concise.

J. K. F.

The Iron Ores of Missouri. By G. W. CRANE. Cloth; 6½x10 in.;

434 pp.; illus. by photographs, diagrams, and maps. Vol. X., Second series, Missouri Bureau of Geology and Mines, Rolla, Mo., 1912.

This volume contains a detailed account of the iron ore resources of Missouri. Missouri at one time held a prominent position in the production of iron but with the exhaustion of the rich specular ores of Iron Mountain and Pilot Knob the production has dropped off very considerably. At present, interest is being revived in the iron industry with the opening up of the brown ores in the southeastern part of the state.

The following types of deposits have been recognized in the iron-bearing region, which is confined chiefly to the Ozark Plateau: (1) brown ores, including the deposits of primary and secondary limonites in Southeast and Southwest Missouri; (2) hematites of the filled sinks, including the ores of the central Ozark district; (3) specular ores in porphyry, including the deposits in the St. Francois Mountains; (4) hematites of the Carboniferous and Silurian. Only the first three of these have thus far proved to be of economic value.

At present the brown ores are receiving the most attention and the future of the iron industry of the State will probably depend chiefly upon the further development of these deposits. Two types are recognized: primary and secondary. The primary limonites are thought to have been originally precipitated from solution as bog ores which, on elevation of the land, were redissolved and carried downward by percolating waters and redeposited chiefly by replacement of the underlying cherty residual material. Others were precipitated directly by circulating ground waters either along the unconformable contact of the Cherokee and Burlington formations, or within the Burlington itself. The secondary limonite deposits occur buried in a residuum of clay, chert, and sand derived from the weathering of an impure cherty magnesian limestone and sandstone of Cambrian age. An individual deposit sometimes contains as high as 60,000 tons of ore. The ore is thought to have been derived directly through the oxidation of marcasite and pyrite, which were originally deposited in openings in the once overlying limestone and sandstone.

The comparison of the economic value of these brown ores with those of the Birmingham district of Alabama, which the writer makes, is hardly a fair one, even if the ores do contain 2 to 7 percent. more iron. The Alabama ores are situated near a well-established smelting center which does not have to depend on these ores alone, but draws a steady supply from the extensive Clinton ores of the district. Transportation charges are low, and fuel and flux conveniently near at hand, so that smelting costs are low. This is not the case with the Missouri ores.

The latter two-thirds of the book is devoted to a description of the individual mines and prospects of the State. This makes the book very valuable to a person desiring information on any particular property.

CHAS. R. FETTKE.

De Re Metallica by GEORGIUS AGRICOLA, translated from the First

Latin Edition of 1556 by HERBERT CLARK HOOVER and LOU HENRY HOOVER, Vellum; folio; xxxi+640 pp. Mining Magazine, London, 1913. Price $8.00 net, duty paid.

The appearance of a translation into English of Agricola's famous treatise on mining is an event of great interest to the profession. Most of us are familiar with the big folio volume with its hundreds of quaint illustrations, though but a few of us, I fancy, have had the courage to attempt to read many pages of the Latin text. This English edition is, however, much more than a translation, as Mr. Hoover has added introductory chapters, and an appendix, these containing among other things a sketch of the life of Agricola and an essay on his intellectual attainments and position in science, and a bibliography and review of his writings, as well as of the writings of ancient and medieval authors on mineralogy, geology, mining and metallurgy. In the text are numerous historical foot notes on alchemy; on the ancient mines of Laurium; on medieval views regarding ore deposits; on the early development of mining law; on medieval mineralogy with names of the known minerals in Latin, German and English; on the mechanical appliances used in mining; on assaying; on the use of the touchstone; on crushing and concentrating of ores; on liquation, amalgamation, parting, and other metallurgical processes; and on the early methods for the manufacture of chemicals. These notes add greatly to the value of the book and indicate most indefatigable research on the part of the author; by themselves they would constitute a fair sized volume.

Georgius Agricola, whose German name was George Bauer, was born in Saxony, March 24th, 1494, and died Nov. 21, 1555. He was thus a contemporary of Luther 1483- 546, of Erasmus 1467-1536, of Melanchthon 1497-1560, of W. Meurer, 1513-1585 and of G. Fabricus 1516-1571. Agricola was one of that company of scholars who contributed to the revival of learning and the re-awakening of the arts and sciences, known as the Renaissance, which begun in Italy and later spread through Germany and Europe.

Agricola was a scholar of high attainments and wide learning. He received the degree of Bachelor of Arts at the University of Leipzig in 1517, where he was afterwards a lecturer between 1522 and 1524. He also studied at the Universities of Bologna and Venice and probably at Padua for nearly three years between 1524 and 1527. Returning to Germany he was made town physician of Joachimsthal in 1527, where he spent about three years and devoted all his spare time to visiting mines and smelters; in reading ancient classics and manuscripts bearing upon mining, and in association with the most learned and skillful among the mining folk. In 1530 he published his first book on mining, *Bermannus,* in the form of a dialogue on mineralogy, mining terms and mining law. After devoting two or three years to travel and study among the mines, he began his great treatise, *De Re Metallica,* which was not published until twenty-five years later. About 1533 he became city physician of Chemnitz and here he lived until his death in 1555. He was a share-holder in "God's Gift" mine

at Alberthau, which was discovered in 1530, and obtained dividends therefrom for many years. He was a recognized authority on mining matters and was frequently called upon for advice. In 1546 he was made burgomaster of Chemnitz and in that capacity attended the Diets of Freiburg, Leipzig, Dresden, etc. He frequently served the Duke of Saxony as an adviser in matters of state and was sent on diplomatic missions to other rulers. In these and similar capacities he continued in public service with short intermissions until the time of his death.

Agricola was a deep thinking religious man, and while liberal in such matters he remained a staunch Catholic and steadily refused to accept the Lutheran Reformation. The character and ability of the man are evident from the fact that he was on terms of intimate and cordial friendship with the great leaders of the Protestant Reformation and commanded the respect and confidence of the Protestant rulers of a state "seething with militant Protestantism."

In addition to the two books mentioned Agricola was the author of many treatises on natural science, which are reviewed by Mr. Hoover in the appendix. Among these are "*De Natura Fossilium*" which is the first attempt made at systematic mineralogy on the basis of solubility, fusibility, odor, taste, etc. Dana, among some four score minerals described by Agricola and his predecessors, credits a score to Agricola himself.

Another book is "*De Ortu et Causis Subterraneorum*" consisting of five chapters on geological phenomena. He was probably the first to recognize that the topographic features of mountainous regions are primarily due to the erosive action of wind and water.

Agricola projected a complete series of works covering the whole range of subjects relating to minerals, mineralogy, geology, mining, metallurgy, history of metals and their uses, mining laws, etc. While many of these books were completed in manuscript they failed of publication mainly through the lack of interest on the part of his heirs.

Mr. Hoover says in his preface "We do not present *De Re Metallica* as a work of practical value" . . . Nevertheless we venture to quote a few paragraphs from Book II in which Agricola gives advice as to mine management and upon mines as a business investment. As will be seen Agricola was not altogether ignorant of what we now style "efficiency engineering" and found it as necessary to warn investors against "wild-cat mines" as we do today.

"It is not sufficient for any one to store away in his mind knowledge of all the departments of the metallic art without regard to the outlays that must be made upon mines or without experience in undertaking and carrying through the practical work." . . . "When any one in an endeavor to increase his fortune meets the expenditure of a mine alone it is of great importance that he should attend to his works and personally superintend everything that he has ordered to be done. For this reason he should either have his dwelling at the mine, where he may always be in sight of the workmen and always take care that none neglect their duties, or else he should live in the

neighborhood so that he may frequently inspect his mining works. Then he may send word by a messenger to the workmen that he is coming more frequently than he really intends to come, and so either by his arrival or by the intimation of it, he so frightens the workmen that none of them perform their duties otherwise than diligently. When he inspects the mines he should praise the diligent workmen and occasionally give them rewards that they and the others may become more zealous in their duties; on the other hand, he should rebuke the idle and discharge some of them from the mines and substitute industrious men in their places. Indeed the owner should frequently remain for days and nights in the mine, which in truth is no habitation for the idle and luxurious; it is important that the owner who is diligent in increasing his wealth, should frequently himself descend into the mine, and devote some time to the study of the nature of the veins and stringers, and should observe and consider all the methods of working, both inside and outside the mine. Nor is this all he ought to do, for sometimes he should undertake actual labor, not thereby demeaning himself, but in order to encourage his workmen by his own diligence, and to teach them their art, for that mine is well conducted in which not only the foreman but also the owner himself gives instruction as to what ought to be done." . . .

"When several share together the expenditure on a mine it is convenient and useful to elect from among their own number a mine captain and also a foreman. For, since men often look after their own interests but neglect those of others, they cannot in this case take care of their own without at the same time looking after the interests of the others, neither can they neglect the interests of the others without neglecting their own. But if no man amongst them be willing or able to undertake and sustain the burden of these offices, it will be to their common interest to place them in the hands of the most diligent men." . . .

"When a man owns mines but is ignorant of the art of mining then it is advisable that he should share in common with others the expense, not of one only, but of several mines. When one man alone meets the expenses for a long time of the whole mine, if good fortune bestows on him a vein abundant in metals, or in other products, he becomes very wealthy; if on the contrary, the mine is poor and barren, in time he will lose everything which he has expended on it. But the man who, in common with others, has laid out his money on several mines in a region renowned for its wealth of metals, but rarely spends it in vain, for fortune usually responds to his hopes in part. For when out of twelve veins in which he has a joint interest one yields an abundance of metals, it not only gives back to the owner the money he has spent, but also gives a profit besides; certainly there will be for him rich and profitable mining, if of the whole number, three, or four, or more veins should yield metal." . . .

"Some owners prefer to buy shares in mines abounding in metals rather than to be troubled themselves to search for the veins; these men employ an easier and less uncertain method of increasing their property. Although their hopes in the shares of one or another mine may be frustrated, the buyers of shares should not abandon the rest of the mines, for all the money expended will be recovered with interest from some other mines." . . . "Moreover a prudent owner, before he buys shares, ought to go to the mine and carefully examine

the nature of the vein, for it is very important that he should be on his guard lest fraudulent sellers of shares should deceive him." . . . "Nor ought miners to be altogether distrustful of fortune, as we see some are, who, as soon as the shares of any mine begin to go up in value, sell them, on which account they seldom obtain even moderate wealth."

Translation of Agricola's book has been attempted by others but we believe this to be the first time that the work has been done by anyone having the necessary scholarship combined with the practical knowledge of the art of mining required for the purpose. Mr. Hoover in his preface outlines some of the many difficulties that had to be mastered, but for these we must refer the reader to the book itself. The work has been a labor of love which has occupied the spare time of a busy professional man for a period of about five years. The printing and distribution of the book is a princely gift to the profession, as the translators have expended on the preparation and publication several times the nominal price at which the edition will be sold. We owe to Mr. Hoover and to his talented wife our hearty thanks for their unselfish devotion to the task which they have done so well and we feel sure that copies of Hoover's Agricola will have an honored place in the libraries of many generations of mining engineers in the centuries to come.

H. S. M.

Chemical Arithmetic and Calculation of Furnace Charges. By REGIS CHAUVENET. Cloth; 6½ x 9½ in.; 302 pp. J. B. Lippincott Co., Philadelphia. 1912. Price $4.00.

The first 206 pages of this book deal with chemical arithmetic. Starting with the fundamental laws and definitions, thermometers, metric system, and conversion, the chemical equation is first taken up, with the method of deducting analysis from formula, and vice versa. Next come vapor densities, and molecular weights, Raoult's law, freezing and boiling points of solutions, then computation of gas volumes, the "Crith" and 22.4 methods for deducing gas volumes from weights, etc., Charles' law and Boyle's law. Specific gravity and methods for its determination are next explained, followed by a section on calculation of analyses, miscellaneous problems, tables of chemical factors, specific gravities and melting points.

Part 2, of 100 pages, is devoted to furnace charge calculation, and includes problems on calculation by excess, allowances for matte composition, etc. Formulistic and "percentage slags" are discussed. The "representative" method in a complete iron-furnace problem is given, followed by slag calculation for copper-matte operation, for lead smelting, for "self-fluxing ores," and finally for indeterminate cases, where several mixtures may produce the required condition.

The book is well written, and the treatment is such that what is often considered a very dry subject is made extremely interesting. The steps are logical and simple, without any wide gaps or jumps which usually bewilder the beginner; at the same time the subject is not made unduly long nor cumbersome. The work will undoubtedly be very useful both in the classroom and also to a man in charge of a plant.

W. C.

UNIVERSITY NOTES.

Geology.—Two special lectures were given on Feb. 18 and 19 by N. H. Darton, of the U. S. Geological Survey. The first was on "The Geological Structure of the Northern Anthracite Field, as Determined by Deep Boring and by Mining." The second was on "The Construction of Maps showing Artesian Water Locations."

Highway Engineering.—During March, the following public lectures were delivered at the University by non-resident lecturers in highway engineering:

March 4—"Organization of Municipal Highway Departments," William H. Connell, Chief, Bureau of Highways and Street Cleaning, Philadelphia, Pa.

" 6—"Metropolitan Park Systems," John R. Rablin, Chief Engineer, Massachusetts Metropolitan Park Commission, Boston, Mass.

" 11—"Manufacture of Wood Paving Blocks," A. W. Dow, Chemical and Consulting Paving Engineer, New York City.

" 13—"Methods of Paying for the Construction of Street Pavements," Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City.

" 18—"Details of Construction of Car Tracks in City Pavements," George W. Tillson, Consulting Engineer, Borough of Brooklyn, New York City.

" 20—"Interrelationship of Highways, Waterways and Railways," John A. Bensel, New York State Engineer, Albany, N. Y.

" 21—"Highway Specifications from the Standpoint of the Contractor," D. L. Hough, President, The United Engineering and Contracting Company, New York City.

Metallurgy.—On Feb. 21, a special illustrated lecture, "Mine to Moulder," was given by Mr. H. B. B. Yergason, of Rogers, Brown & Co. The illustrations were moving pictures, covering all the steps in the mining, transporting, loading and unloading and smelting the ore, concluding with the bessemer process of steel making. Among the most striking pictures were those of the steam shovels at work on the Mesabi range; the loaded trains arriving and discharging at the Duluth docks; loading the lake boats; passing these boats through the Soo canals; unloading the boats at Buffalo; tapping the iron furnaces and handling the pig-iron by magnetic cranes; the operations of the bessemer converter and casting the steel ingots; and finally rolling the ingots by stages down to steel rails.

Mining.—R. V. Norris, E. M., 1885, consulting engineer of the D. L. & W. Coal Co., Wilkesbarre, Pa., gave a series of three lectures in February on the methods and plant for ventilating coal mines, a subject on which he rates as an expert. In March he gave another series of four lectures, two on mine drainage, by pumping and hoisting, and two on power plants for collieries.

Civil Engineering Society.—At a meeting of the Civil Engineering Society on Tuesday evening, March 4, Mr. E. C. Church, C. E. '04, of the Department of Water Supply, Gas and Electricity, New York City, gave a very interesting talk on the organization and methods of the Bureau of Purchases and Supplies of that Department. Mr. Church pointed out that this bureau expended yearly an appropriation of about $20,000,000 for supplies of all kinds, from matches to pumping engines. The organization of the bureau to get "the right material in the right quantity at the right price" was briefly reviewed. Centralization of the purchasing for the four different boroughs, and quarterly requisitions with deliveries to central points, have permitted the purchase of supplies in bulk. Carefully prepared, clearly written, effective and definite specifications, together with prompt acceptance of bids, quick inspection and payment, have encouraged competition. The organization of the store rooms so that material is issued in the proper manner, and the requirement that all old tools must be returned when new ones are issued to replace them, has led to an economical and effective management of this bureau, under Mr. Church's direction.

The talk was well attended and thoroughly enjoyed by the members of the society from the Senior and Junior classes. "Refreshments" were served in the commons, following the lecture.

J. K. F.

Electrical Engineering.—The senior class of electrical engineers accompanied Professor Slichter, during the Easter holidays, Mar. 20-24, on a trip of inspection, during which they visited the factory of the General Electric Co., at Schenectady, and the hydro-electric plant on the Hoosic River at Schaghticoke, N. Y.

Mechanical Engineering Society.—At a meeting in the evening of Mar. 6, Prof. C. P. Berkey, of the Department of Geology, delivered an illustrated lecture on the "Construction of the Catskill Aqueduct." Prof. Berkey, as expert for the city, has obtained intimate knowledge of the geological conditions and the engineering difficulties encountered in developing this great system of water supply for New York City. His description covered the construction of the aqueduct from the Ashokan reservoir to the point at which the water is delivered in mammoth tunnels underneath the city.

Phi Lambda Upsilon.—At a meeting of this honorary chemical society, in the evening of Mar. 6, Dr. F. K. Cameron, of the Bureau of Soils of the United States Department of Agriculture, spoke on "The Solution of the Potash Problem in America." Potash is a necessity

as a fertilizer and Germany controls the market. Therefore the Department of Agriculture has made extensive experiments in an endeavor to find some way of producing this important chemical so that it can be sold at a reasonable price.

School of Mines Centennial Committee.— The Chairman of the Board of Trustees, pursuant to a recent resolution of the Board, has announced the following committee on the semi-centennial of the School of Mines, to be commemorated in 1914:

Representing the Board of Trustees.— Benjamin B. Lawrence, '78, Chairman; William Barclay Parsons, '82, William Fellowes Morgan, '84. Representing the Faculty of Applied Science.— Dean Frederick A. Goetze, '95, Professor Henry S. Munroe, '69, Professor James F. Kemp, '84. Representing the Alumni.— Arthur S. Dwight, '85, Daniel E. Moran, '84, Thomas B. Stearns, '81.

Y. M. C. A.—Under the auspices of the Christian Association, Dr. William H. Tolman, Director of the American Museum of Safety Appliances on Mar. 5, delivered an illustrated lecture on "How to Prevent 50 percent. of the Needless Waste of Human Lives through Accident and Disease." The lecture was primarily intended to acquaint the engineering students with the rapid developments that are taking place within the engineering and allied professions to conserve the human resources of the nation.

Beginning on Feb. 18, Dr. George L. Meylan, Director of the Gymnasium, delivered a course of lectures on "First Aid to the Injured," to which the senior students in mining were specially invited, and were strongly urged by the Department of Mining to attend. In our opinion, this ought to be a required course for students in mining.

Electrical Engineering Society. On Dec. 12, 1912, Mr. R. B. Treat of the Crocker-Wheeler Co., addressed the Electrical Engineering Society on the subject of "The Application of Electric Motors to Steel Mills." Mr. Treat showed that the application of motors to this type of work involved very special conditions, necessitating the development of a special type of motor and requiring great care in the application to see that the motor is particularly suited to the work. The prime quality required of all apparatus in steel mills is reliability, as a stoppage of a few minutes, due to a fault in the apparatus, may permit the metal to cool, solidify, and block the different channels, and it is a very difficult and tedious task to chip out solid metal which has solidified where it is not wanted. Motors for this service are therefore made with liberal overload capacity, both as regards electrical constants and mechanical strength. As most of this work involves starting and stopping very frequently, the ability of the motor to start and its flywheel effect are very important and it is desirable, in fact, necessary, to design a motor with very small flywheel effect. In some of the old motors most of the energy consumed was wasted in braking the armature of the motor itself. Thus by merely changing the proportions of the armature an enormous economy of energy was made.

On Feb. 13, 1913, Mr. F. B. Corey, Engineer of Test and Inspections of the Union Switch and Signal Co., gave a lecture before the Society on the subject of "Railway Signals." He devoted a short portion of his address to the subject of mechanical interlocking systems as used in terminals, but dwelt more at length on the principles and methods of applying electricity to block signals for main line work. He showed the development of a block signal from staff systems, in which the right to move on a certain block was granted by the physical possession of a certain piece of iron called a staff; next followed the development of a system which would permit two or three trains in succession to pass through the block in the same direction and yet prevent another train from entering in the opposite direction until the block was vacated. He then spoke of the development of the block system, in which the two running rails are kept at a difference of potential when the track is cleared and this difference of potential keeps the signal at the end of the block at the safety position. As soon as a train enters a block its wheels and axles short circuit the rails, the difference of potential disappears, and the signal falls to danger. With the development of electric traction, block signals became necessary, but difficulties were introduced since the motive current from the train, returning through the rails, would interfere with the signal system. At first it was attempted to set aside one rail to carry the motive current, leaving the other free for signal purposes, but even then the service was not satisfactory and it was necessary to insert extra feeders to make up for the lost conductivity of the other rail. It was then that the method was devised of using alternating currents for the signal system and restricting their passage along the path taken by the motive current by the introduction of reactance bonds between the rails, which prevented the flow of alternating current but permitted that of the direct current. Mr. Corey mentioned that in the development of this system two Columbia men were among the pioneers, namely C. F. Townsend, '96, and W. I. Slichter, '96.

On Thursday evening, Feb. 27, 1913, Mr. F. H. Blake of the Pittsfield factory of the General Electric Co., addressed the Society on the subject of "Arc Lighting and Theatre Lighting." Mr. Blake in his preliminary remarks discussed the transformation of electric energy to light energy by means of heat, incandescent and selective radiation, and pointed out that the limits of efficiency by incandescence were very definite and very low, but that by means of selective radiation great improvements might be expected. He described selective radiation as due to the vibrations of elements in a gaseous state brought up to a temperature where they could vibrate at a frequency natural to each particular element. Thus selective radiation involves the use of a gas as compared to a solid. He mentioned the mercury arc as one of the neatest examples of selective radiation and then took up the subject of introducing selective radiation into the arc lamp by combining with the carbon of the electrodes various substances such as calcium, barium, titanium, which, when volatilized by the temperature of the arc, would

impart to the light of the arc a brilliancy and color due to their own special pecularities. He mentioned the magnetite arc lamp, which has become very general for street lighting, but is not well adapted for use on alternating currents, and finally dwelt on the progress in the use of carbons impregnated with calcium to give the effect of the flaming arc lamps which are now becoming very generally used for display lighting. Mr. Blake mentioned the fact that whereas these lamps could hitherto be built for a life of only about 17 hours per trim they were now being manufactured for a life of over 100 hours, both for alternating- and direct-current work.

W. I. S.

Sigma XI.— The annual election of officers and new members was held on Wednesday evening, Mar. 12. Vice-President Walker presided, and Prof. H. E. Hawkes acted as secretary; about 30 members were present.

The following new members were elected: From the Faculty and graduate students.— Thomas S. Fiske, Frank N. Cole, James Macklay, Edward Kasner and Gabriel M. Green, from the department of mathematics; Robert K. Murphy, William C. Moore, Arthur Edgar, Robert P. Calvert, Walter W. McKirahan, Sidney Born, Carl Haner, and Edward Shramm, from the department of chemistry; Clemens Liebling and Ferdinand F. Hintze, from the department of paleontology; Alfred J. Brown and Frederick Tilney, from the department of anatomy; and Julian Blanchard, from the department of physics. From the Undergraduates.— Wheadon M. Grant, Louis W. Hickey, George A. Prochazka, George F. Schattinger, mining engineers; James L. Cheatham, Gilbert D. Fish, George R. Genung, Gerald P. Peet, Elmer Roberts, Walter Steinbruch, civil engineers; Cornelius Kroll, electrical engineer; M. H. C. Brombacher, L. Grossbaum, Albert H. Israel, Edwin W. Stone, mechanical engineers; Reed W. Hyde, Edward H. Koenig, metallurgists; Morris G. Sheppard, chemical engineer; Samuel B. Applebaum, sanitary engineer and J. M. Bird, of the College.

The following officers were elected unanimously, to serve two years: *President,* C. P. Berkey; *Vice-President,* H. E. Hawkes; *Recording Secretary and Treasurer,* J. K. Finch; *Corresponding Secretary,* J. H. Morecroft. Refreshments were served after the meeting.

Geological Journal Club.— At the meeting on Jan. 15, Mr. E. L. Bruce reviewed A. H. Phillips' new mineralogy entitled "An Introduction to the Theoretical and Practical Study of Minerals," recently published by the Macmillan Co. This book is intended as a text-book for an elementary course in mineralogy but differs somewhat from most mineralogies in that the origin of the different minerals is discussed. The book contains tables for blow-pipe and optical tests. Mr. J. Jensen reviewed Prof Heinrich Ries' new book, "Building Stones and Clay Products," published by John Wiley & Sons. The first part of this book treats of those phases of geology which have a bearing on the subject in hand; the second part is devoted to the economic side; while the third part discusses the utilization of these materials and their

manufacture into different products. The fire-resisting qualities of different kinds of building materials are discussed and examples of buildings constructed of particular kinds of stone in different parts of the country are given. Mr. F. F. Burr reviewed M. L. Fernald's work on the distribution of the different floras of Newfoundland. This paper is of geological interest on account of the close relationship shown by the floral distribution to the underlying geological formations. Miss M. O'Connell reviewed Clark and Ruedeman's new memoir on The Euripterida of New York. Finally, Professor William M. Davis gave an interesting demonstration on how to draw block diagrams.

Prof. Kemp, who has returned from a half-year's leave of absence, presided at the meeting on Feb. 5. Mr. W. H. Emmons reviewed a paper by George H. Hudson on a fossil starfish found near Ottawa, Canada, in the Black River limestone of that vicinity. Mr. Chas. R. Fettke reviewed "The Iron Ores of Missouri," by G. W. Crane. This is one of the publications recently issued by the Missouri Bureau of Geology and Mines. A review of this book by the writer appeared in the last number of the QUARTERLY. The last paper of the evening was one by Mr. F. M. Van Tuyl on the geodes of the Keokuk beds of the central Mississippi Valley. This paper considered chiefly the occurrence, mineral composition, and origin of the geodes, based upon field work done by Mr. Van Tuyl during the summer of 1911. The feature brought out of most significance was a new theory for their origin. After previous theories had been discussed and shown to be untenable it was pointed out that the geodes were closely related to calcareous nodules which occur in the beds at some localities. The steps involved in the derivation of the geodes from such nodules were believed to be as follows: (1) the growth of the nodules by the segregation of calcareous material on the sea bottom; (2) the development of siliceous shells upon these nodules; (3) the removal of the enveloped nodules by solution; (4) the deposition of mineral matter upon the inner walls of the empty siliceous shells.

Prof. D. W. Johnson presided at the meeting on Feb. 19. After he had called attention to the current literature on geological subjects, Mr. G. S. Kearney reviewed Professor Woodworth's report on the Shaler Memorial expedition to Brazil and Chili. Devonic sediments occur resting on the pre-Cambric in the portions of Brazil visited. These are followed by the Permic, in which evidences of glaciation are found; these are discussed in some detail. Triassic trap flows, correlated with the Newark flows of New Jersey, occur. Mr. C. C. Mook gave an account of the work Prof. Osborn is doing in connection with the preparation of a monograph on the sauropod dinosaurs. Mr. Mook is assisting Prof. Osborn in this work. He illustrated his talk with a life size drawing of a skeleton of a comarasaurus dinosaur, which covered a whole wall of the large laboratory in which the meeting was held. Dr. C. Sebling gave an account of some observations that he had made during the past summer on several thrust and normal faults occurring in Stissing and Schunemunk mountains north of the Highlands of the Hudson.

At the meeting on March 5th Professor Kemp exhibited new specimens recently acquired by the museum. Dr. Charles T. Kirk, of the City Normal College, reviewed W. H. Weed's report on the geology and ore deposits of the Butte district, Mont., which was recently published as Professional Paper No. 74 by the U. S. Geological Survey. The paper gives a very good description of the local geology and ore deposits, but many problems of intense scientific interest are still unsolved. Mr. J. Jensen reviewed Roald Amundsen's recently published book on the South Pole. About seven-eighths of the book, which appears in two volumes, is occupied by a narrative account of the expedition itself, while the other one-eighth deals with scientific matters. The region around the pole is an immense plateau 10,260 ft. high, probably underlain by pre-Cambric rocks which are flanked by Palæozoics.

CHAS. R. FETTKE.

Civil Engineering Department.—At the meeting of the Trustees on April 7, Leonard D. Norsworthy, Instructor in charge of the testing laboratory, was promoted to be Assistant Professor, to take the place of Prof. J. P. J. Williams, resigned. Mr. Daniel D. Jackson was likewise appointed Assistant Professor of Civil Engineering, to have special charge of the course in sanitary engineering.

FACULTY NOTES

Professor Robert Peele, of the Department of Mining, has been engaged by Messrs. John Wiley & Sons, of New York, to prepare a "Mining Engineers' Pocket-Book." In compiling the book, the aim will be to supply technical information and data in concise and convenient form for the use of mining engineers, both in the field and in their offices. Illustrative examples from practice, with numerical details, will be freely used. The bulk of the subject-matter will be contributed by a number of associate editors, who are specialists in their several lines. The tentative table of contents and the assignment of sections to the associate editors is nearly completed; the indications are that the book will contain 1200 to 1400 pages.

At a meeting of the society, The Municipal Engineers of the City of New York, on Feb. 26, Professor Arthur H. Blanchard, delivered an illustrated lecture on "The Highways of Europe." Professor Blanchard has lately been appointed by Governor Sulzer to be a member of an advisory commission on highway construction in the State of New York.

Professor M. T. Bogert, of the Department of Chemistry, President of the Society of Chemical Industry, was the guest of honor at a meeting of the Societa Chemica Italiana in Rome, on March 16. Professor Bogert spoke on Chemistry in America, with particular reference to the organization of the American Chemical Society.

ALUMNI NOTES.

At the last annual meeting of the American Institute of Mining Engineers, Feb. 17, 19 3, the names of Columbia men were prominent. Professor Kemp, as retiring president, entertained the opening meeting with one of his quasi-serious humorous papers, and on the next day delivered a scholarly address on "The Ground-waters." Karl E. Eilers, E. M., '89, T. H. Leggett, E. M., '79, and F. W. Denton, C. E., '89, were elected vice-presidents. E. L. Young, E. M., '82, and John H. Janeway, E. M., '86, were elected to the board of directors, on which G. C. Stone, Chem., '79, holds over from the old board. Mr. Stone has been recognized as leader of the opposition to the proposed constitutional amendments aiming to increase dues, classify the membership, and provide for "Fellows" of the Institute. At the first meeting of the new board of directors, next day, Bradley Stoughton, formerly Instructor in the Columbia Department of Metallurgy, was elected Secretary of the Institute, to succeed J. Struthers, '85.

1868. Lenox Smith, E. M., who has been a Trustee of the University since 1883, offered his resignation at the meeting of the Board on April 7, on account of ill-health.

1878. Richard A. Parker, E. M., has been appointed consulting engineer by the El Paso Gold Mining Co., of Cripple Creek, Colo. He was lately elected a vice-president of the Colorado Scientific Society.

1883. W. H. Weed, E. M., has recently returned to New York from an extended professional trip through the southwest, and Sonora.

1883. On February 11, fourteen members of Eighty-Three Mines met at dinner at the Columbia University Club. This class began to get together for occasional dinners ten years ago and a number of reunions have since been held. Those who attended on the present occasion were: Balch, Brewster, James Brown, Calhoun, Carrère, Mulford, Peele, Reed, Renault, Richardson, Stearns, Suter, Tibbals, and Walker. Letters of regret were read from a number of absent members of the class, two of them being nearly at the other side of the Continent.

The immediate object of the gathering was to discuss the plan of providing a suitable setting and marble base for the fine bronze bust of Professor Egleston, now in the entrance hall of the School of Mines. A drawing of the proposed niche and base, made by the architects of the building, was exhibited, and it was unanimously decided to make this gift to the University on the thirtieth anniversary of the class, to be held this year. All who have seen the present temporary wooden support of Professor Egleston's bust realize the need of an appropriate setting for the memorial of one of the founders of the School of Mines.

Of the $450 pledged by the class for this purpose, the sum of $390 was presented to the Trustees, and gratefully accepted by them on Mar. 3, 1913.

1885. Charles H. Doolittle, E. M., is general manager of the Bingham-New Haven mine, at Bingham, Utah, and also secretary of the Salt Lake City Columbia Alumni Association.

1891. Gano Dunn, E.E., has been made President of the J. G. White Engineering Corporation, a subsidiary of J. G. White & Co., New York.

1892. The regular midwinter reunion of the Class of '92, Arts and Mines, was held at the Columbia University Club, January 21, 1913. The following were present: Briggs, Brown, Brownson, Buckley, Burchell, Chapman, Childs, Chrystie, Dufourcq, Fiske, Granger, Hall, Hewlett, Hyde, Kletchka, Knap, Knox, Lord McIlhiney, McKinlay, Pierce, Sinsheimer, Travis, Trippe, Vail, Windolph, Zinsser. President Chrystie presided. After dinner, Knox, who designed the elevator equipment of the Woolworth Building, explained how he worked out the solutions of the problems involved. Some of these elevators have the extraordinary rise of 680 ft.

Briggs, who is Executive Secretary of the Court House Board, explained the proposed Court House-Civic Centre project, which will make New York a real "city beautiful." Chinatown, Baxter Street, and other dark though historic spots are to be replaced by broad boulevards, furnishing a proper setting not only for the new Court House for the State and City Courts, but also for an adequate Federal Court House and for a building to house all the State departments having offices in this city, and for a Criminal Courts Building.

The next meeting of the class will be at the University Commencement Day, June 4, 1913.

1895. F. Hedley Jobbins, Ph.B., was in the East during the early spring in connection with the introduction of the Kiebitz process of soap making. The process has been largely adopted in Europe and is being looked favorably upon by manufacturers in this country. Mr. Jobbins is vice-president of the Kiebitz Process Co. of America, which is one of several corporations controlled by the Wm. F. Jobbins, Incorporated.

1895. Charles S. Herzig, E. M., during March delivered a series of six lectures on "Mine Sampling" before the Sir John Cass Institute, an organization of English mining engineers. The lectures will later appear in book form.

1895-99. At a meeting held at the Columbia Club, New York, Feb. 24, arrangements were made to form a new association of Alumni, to include '95, '96, '97, '98, and '99 Arts and Mines. The first meeting will be held on April 11, at which a name will be adopted and permanent officers elected. W. I. Slichter, E. E., '96, is temporary chairman, and T. P. Keppel, '98 C., is temporary secretary.

1896. Edwin C. Holden, E. M., Professor of Mining at the University of Wisconsin, Madison, Wis., visited New York in February.

1897. I. O'Reardon, C. E., is manager of the Javali mine, near Santo Domingo, Nicaragua.

1898. A. P. Rogers, C. E., of New York has recently been engaged in professional work near Seattle, Wash.

190·. Clarence M. Schwerin, E. M., No. 1 Broadway, New York, is General Manager of the Vinton Colliery Co.

1902. C. P. Crissey, Mech. E., was recently elected to membership in the A. S. M. E. He is now employed by the Henry R. Worthington Company, 115 Broadway, New York. A book, "Centrifugal Pumps," of which he was part author, has recently been published by D. Van Nostrand.

1902. Walter P. Hatch, Mech. E., is now connected with H. W. Caldwell & Sons, 50 Church St., New York.

1902. E. F. Pelton, E. M., for several years geologist for the Detroit Copper Co., at Morenci, Ariz., has returned to Columbia for a half-year's advanced study under the department of geology. On his return to Arizona, he will be connected with the Phelps-Dodge interests, with office at Bisbee.

1902. Frederick H. Morley, E. M., of Denver, is spending the winter with his mother in Egypt.

1902. Arthur Feust, E. M., is with the Cedro & Carmen mines, near Santo Domingo, Nicaragua. He reports that he has safely survived the past two years during which has occurred one of the most violent revolutions that has ever troubled that country.

1902. Alfred Williamson, Mech. E., who is engineer with the New York City Department of Water Supply, was recently elected a Trustee of Bronxville, N. Y.; he is also a member of the Village Planning Commission.

1903. A class dinner, attended by both college and engineering graduates, was held at the Republican Club, New York, on Tuesday evening, March 25. Over 100 members of the class were present. After a most excellent dinner, a few brief remarks were made by those members who have in hand the preparations for the decennial celebration in June. After the speeches, an exhibition of the famous Paul Rainey African hunting moving pictures was given.

1903. H. J. Barling, E. M., and H. L. Mead, E. M., 1904, have gone to Colombia to assist F. Lynwood Garrison, of Philadelphia, in the exploration of gold placer lands owned by the Breitung Mines Corporation, with headquarters at Barranquilla.

1903. At the Bingham-New Haven mine, Bingham, Utah, F. M. Wishman is superintendent of mines and J. F. Bauchelle is superintendent of mill.

1903. S. F. Shaw, E.M., in charge of the Tiro General mine at Charcas, San Luis Potosi, Mexico, reports that after an engagement with revolutionary bandits in February, in which nine of the latter

were killed, he escaped with the women and children of the camp to San Luis Potosi, but lost all his personal effects. He expects to return with a military guard and resume operations at an early date.

1904. Charles T. Law, E.M., is now at Nevada City, Cal., P. O. Box Q.

1904. H. Harold Higbie, E. E., after serving as Instructor in Mechanical Engineering, then as Instructor and Assistant Professor of Electrical Engineering at the University of Michigan, went to Boston to organize the electrical department of the new Wentworth Institute. He will return to Ann Arbor, Mich., in the fall of 1913, as Professor of Electrical Engineering. He has recently been elected President of the National Executive Council of the Tau Beta Pi Association, of which he has been an active and influential member since his undergraduate days.

1905. M. Gardner Talcott, who for the past five years has been engineer with the Arizona Copper Co., at Morenci, Ariz., is now connected with the Dome Mines, Ltd., South Porcupine, Ontario.

1905. Jesse C. Porter, E. M., has recently returned to New York after two years in Costa Rica. His address for the time being is 1005 E. 17th St., Brooklyn.

1905. Andrew Walz, E. M., is occupied in a mining investigation in the interior of Lower California, Mexico.

1905. George Miltenberger, Jr., E. M., has left St. Louis and has gone to Rio Del Monte, Hidalgo, New Mexico.

1906. Mortimer Freund, E. E., chief engineer for Percival R. Moses, '95, consulting engineer in New York, was recently promoted to full membership in the A. I. E. E. During the past winter, he spent much of his time in Canada, supervising the installation of engineering equipment in two large department stores being erected by the Hudson's Bay Company, one at Alberta, and the other at Vancouver.

1906. H. H. Goodwin, C. E., of Briarcliff Manor, N. Y., announces the birth of a daughter, Eleanor Mary, on Feb. 13, 1913.

1906. Lloyd M. Kniffin, E. M., formerly at Steeple Rock, N. M., is now connected with the United States Metals Refining Co.; he is at present in charge of construction work on the company's electrolytic lead refinery at Grasselli, Ind.

1906. DeWitt C. MacKallor, E. M., was married in Denver last December; his address is Lluvia de Oro, Chihuahua, Mexico.

1906. Charles S. Thomas, Jr., is consulting engineer for the Humboldt Mining Co., with office at Denver, Colo.

1906. Alfred W. Evans, E. M., lately of Durban, Natal, is now general manager of the United Gold Fields of New Zealand, Ltd.

1906. Roger W. Toll, C. E., has been appointed chief engineer of the Denver City Tramway Co., Denver, Colo.

1906. Albert G. Suydam, E. M., has resigned his position as general manager of the Revenue Tunnel Mines Co., at Boulder, Colo., which he has held during the last three years, to become metallurgist for the Ohio Copper Mining Co., at Lake, Utah.

1906. Frank T. Eddingfield, E. M., is acting chief of the division of mines in the government of the Philippine Islands, with which he has been associated during the past four years. Previously he has been connected with El Cobre mines, Santiago, Cuba; with a lead-silver mine near Deer Lodge, Mont.; and with the Delores mine, Chihuahua, Mexico. Present address: 1440 Harvard St., Washington, D. C.

1907. John B. Overbeek, E. M., was married at Cape Town, South Africa, on March 19, 1913, to Miss Millie van Heerden, the daughter of Dr. J. P. van Heerden.

1907. Francis G. Fabian, E. M., formerly of Evanston, Ill., is now at 36 Watson Place, Utica, N. Y.

1907. Morris J. Elsing, E. M., read a valuable paper on "Relation of Outcrops to Ore at Cananea, Mexico" at a recent meeting of mining engineers at Douglas, Ariz. It was reprinted in the *Engineering and Mining Journal* of Feb. 15, 1913.

1908. Lewis M. Jones, E. M., is the author of Miners' Circular 11, "Accidents from Mine Cars and Locomotives," recently published by the U. S. Bureau of Mines.

1908. Charles L. Hall, C. E., was married on Feb. 8, 1913, to Miss Julia A. D. Purvis, at South Edmonton, B. C. Their home will be in Seattle, Wash.

1908. Andrew W. Newberry, E. M., was recently at the University visiting his old friends.

1908. Henry F. Davis, E. M., is now engaged in the Cerro Gordo mine, at Keeler, Cal.

1909. L. M. Bernfeld, C. E., on March 1 delivered a lecture before the Hungarian Engineering Society, of New York, on the subject of Municipal Supervision of Building Work in Manhattan.

1909. Joel A. Battle, E. M., who has been superintendent of the Montezuma Lead Company's mines at Santa Barbara, Chihuahua, Mex., returned to New York in March. Address, 616 W. 113th St.

1909. M. B. Evans, E. M., is assistant manager of the Javali mine, near Santo Domingo, Nicaragua.

1909. E. B. Latham, E. M., for the past year has had charge of the geological work for the Oil Protective Association, formed by all the operators and producers in the Sunset, Maricopa, Midway, McKittrick and Kern River oil fields of California. In future he will act also as consulting geologist for the Santa Fe Railroad's fuel-oil interests in California. Address, Box 53, Taft, Cal.

1910. M. L. O'Neale, E. M., since June, 1911, has been superintendent of the Seaboard Coal and Coke Co., Coal City, Ala., and more recently superintendent also of the Central Coal Co., at Kimberley, Ala.

1910. Charles F. Schnepp, E. M., has recently been engaged in prospecting for nickle ores in the Sudbury district, Ontario, for the American Smelting and Refining Company.

1910. R. A. McGovern, E. M., recently returned from Chuquicamata, Peru, went to Cuba in January to assist in the inspection of an iron ore property near Santiago.

1910. Homer L. Carr, E. M., left New York in February to investigate gold placer deposits near Quibdo, State of Choco, Colombia, South America. He expected to be gone two months.

1910. L. S. Webster, E. E., formerly with the General Electric Co., at Harrison, N. J., is now in the power department of the New York Edison Co., 55 Duane St.

1910. The engagement of T. B. Counselman, E. M., to Miss Eleanor C. Gardner, of New York, is announced. Counselman is now located at Cananea, Mexico.

1910. F. A. Wardlaw, E. M., is on the engineering staff of the Highland Boy mine, Bingham, Utah. So also is J. I. Moore, E. M., '12.

1911. Graham Montgomery, Mech. E., resigned his position with the Henry R. Worthington company in January, and is now connected with the Florida East Coast Railway, at Spanish Harbor, via Marathon, Fla.

1911. W. R. Wright, who was with the Braden copper mine, at Rancagua, Chile, has recovered from his recent severe sickness, and has returned to New York, where he will be employed by a steel company.

1911. Joseph R. Guiteras, E. M., is now engineer with the Horn Silver mine, at Frisco, Utah, under the superintendence of W. H. Hendrickson, E. M., '03.

1911. Richard Cobden, Jr., E. M., recently on the engineering staff of the Bingham-New Haven mine, Bingham, Utah, returned to New York in March.

1911. H. P. Corsa, E. M., on the engineering staff of the Bingham-New Haven mine, Bingham, Utah, was married in September, 1912, to Miss Louise Morrison, of Oxford, England.

1911. A. E. Hall, E. M., for the past two years on the engineering staff of the Dome Mines, Ltd., South Porcupine, Ont., now holds a similar position with the Canadian Copper Co., at Creighton Mine, Ont. He visited New York in February.

1911. Edmund Newton, E. M., is on the staff of the School of Mines at the University of Minnesota, Minneapolis. At present, he

is in charge of the technical work being conducted by the state mines experiment station, recently instituted, which is making a study of the washing of low-grade Mesabi iron ores.

1911. Percy R. Iseman, E. M., formerly with the Yukon Gold Mining Co., at Dawson, Y. T., has lately returned to New York after an extended trip through Chile, Bolivia and Peru, on behalf of the Bolivian Exploration Co. He expects to take up hydraulic mining in California.

1911. Clark G. Mitchell, E. M., is now superintendent of the Isabella Mining Co., at Cripple Creek, Col.

1911. T. M. Bains, Jr., E. M., is now in the employ of the Mariposa Estates, on the Mother Lode, at Mt. Bullion, Cal.

1911. Felix Riesenberg, C. E., who has been assistant engineer on the New York City Board of Water Supply, is now Assistant Superintendent of Parks, Queens Borough, New York. He was married to Maud Conroy, June 29, 1912. He has recently been elected to membership in the Explorers' Club, and reëlected President of the alumni association of the New York Nautical School. Address, 66 Jamaica Ave., Flushing, N. Y.

1911. A. W. Kruemmer, E. M., took the degree of Ph. D. in geology, mineralogy and geography at the University of Koenigsberg, Prussia, in January, 1912. He has been appointed *Bergreferendar* at Barsinghausen (Hanover), Gladbeck (Westphalia), Louisenthal (Saar) and Naumburg (Saale). He contributed articles which appeared in *Zeitschrift für praktischc Geologie,* issues of July and August, 1912. At present, he is in military service with the Dragoner Regt. Freiherr von Manteuffel (Rhein.) Address, Convictstrasse 2 a, Bonn, or 136 W. 44th St., New York.

1911. Walter C. Hill, E. M., assistant statistician of Brown Bros. & Co., bankers of New York City, was recently elected to membership in the American Institute of Banking.

1912. Stuart Levison, Met. E., is employed in the copper smelter of the American Smelting and Refining Co., at Monterrey, Mexico.

1912. Harvey S. Mudd, E.M., of Los Angeles, was married at New York to Miss Mildred Esterbrook, March 12, 1913.

Ferdinand Zogbaum, a former student in the Schools of Engineering, has recently been appointed to the office of Engineer of Maintenance of the New York, Westchester & Boston Railway Co.

In the death of George William Maynard, at Boston, Feb. 13, 1913, the School of Mines loses one of its best friends and most devoted supporters. He was born in Brooklyn in 1839, and graduated from Columbia in 1859, before there was any School of Mines. After

graduating, he spent a year of research in the chemical laboratory, and received a prize in recognition of his work. He then studied for a year at Göttingen, and for another year at the Bergakademie at Clausthal. He received the degree of Master of Arts from Columbia in 1862. After the organization of the Alumni Association of the School of Mines, he was elected an honorary member, and his interests have since been wrapped up in the activities of the School of Mines. It was considered a rare treat to listen to Mr. Maynard's reminiscences of his student days at Columbia, and his connection, a few years later, with the organization and early history of the mining school.

Mr. Maynard was one of the founders of the American Institute of Mining Engineers, and of the Engineers' Club, of New York. He also held membership in many other civic and scientific organizations. He has known, at one time or another, almost every prominent engineer in this country. His particular field has usually been the iron mining and smelting industry, but copper and the precious metals have also engaged his attention. His loss will be felt by the mining profession no less keenly than by the School of Mines.

Harry H. Sutro, chemist, 1898, died on January 20, 1913. Mr. Sutro was a chemist with offices at 136 Liberty Street, New York. He was connected with the L. M. Booth Co., and made a specialty of designing and erecting water purification plants.

John Hawkesworth, C. E., 1904, died recently. For some years after leaving college he was associated with Raymond F. Almiral, architect. He was married within the last six months. Not long since he was elected president of the Carleton Company, building contractors of New York. He was the author of a Graphical Handbook for Reinforced Concrete Design.

ESTABLISHED 1851

EIMER & AMEND

205-211 Third Ave.,
New York City

HEADQUARTERS FOR

Chemicals, Chemical Apparatus and Assay Supplies

Mine Laboratory Supplies

Platinum Ware—best hammered.

Pyrometers, Optical, Thermo-Electric

Electric Furnaces for Laboratory Purposes

Balances and Weights of every Description

Chemicals, Chemically pure and Technical

COMPLETE LABORATORY
AND
PROSPECTING EQUIPMENT

First Quality Supplies Only

Prompt Service

Min & Met
Per 27

VOL. XXXIV. NO. 4. JULY, 1913

THE

SCHOOL OF MINES QUARTERLY.

A JOURNAL OF APPLIED SCIENCE.

CONTENTS

	PAGE
HENRY MARION HOWE. By *Arthur L. Walker*	301
POLARIZING MICROSCOPE IN THE DETERMINATION OF MINERALS OF NON-METALLIC LUSTRE. By *A. J. Moses*	305
CONSERVATION. By *James Douglas*	335
SMELTING IN SHAFT FURNACES AT GREAT ALTITUDES. By *Vincente Pazos y Sacio*	344
ECONOMICS OF MOTOR TRUCKING — II. By *Clinton Brettell*	359
BY-PRODUCTS OF SUGAR MANUFACTURE, AND METHODS FOR THEIR UTILIZATION. By *C. A. Browne*	370
STOPING DRILLS AT SUDBURY, ONT. By *A. E. Hall*	383
RELATION OF PYRRHOTITE TO CHALCOPYRITE AND OTHER SULPHIDES. By *A. P. Thompson*	385
ABSTRACTS — ANALYTICAL CHEMISTRY. By *E. Waller*	396
BOOK REVIEWS	402
ANNUAL MEETING OF THE ALUMNI ASSOCIATION	406
UNIVERSITY NOTES	410
FACULTY NOTES	410
ALUMNI NOTES	417

COLUMBIA UNIVERSITY
NEW YORK CITY

Registered at the New York Post Office as Second Class Matter

TWO DOLLARS PER YEAR. FIFTY CENTS PER NUMBER.

All Remittances should be made payable to order of "The School of Mines' Quarterly

"DENIED"

In connection with our Suit against

The Tonopah-Belmont Development Co.

(Defended by the Butters Filter Co.)

for infringement of the MOORE PROCESS PATENT on a motion made by the defendants for a rehearing of the case, alleging that errors of fact existed on which the previous decision rested, the United States Circuit Court of Appeals for the Third District has issued its decision "denying" the motion for a rehearing. This decision confirms the sweeping judgment recently handed down in favor of The Moore Process Patent.

Verbum Sap.

The Moore Filter Company

New York, U. S. A.

THE
SCHOOL OF MINES
QUARTERLY

VOL. XXXIV. JULY, 1913. No. 4.

HENRY MARION HOWE.

At the end of the present academic year, Professor Henry M. Howe will retire from the Department of Metallurgy of the School of Mines, Columbia University, as professor emeritus. While Professor Howe has not been actively engaged in the administration of the department for the last five years, he has continued his connection by giving certain lectures, and in so doing has kept in touch with the school.

Prof. Howe succeeded Prof. Egleston in 1897 as head of the Department of Metallurgy on the retirement of the latter shortly before his death in 1899, and until 1908 was the administrative and active head of this department. In 1908, Prof. Howe asked to be retired from the active administration of the department, as it was his desire to have ample time for literary duties and for the completion of his new work on iron and steel.

During the years that Prof. Howe guided the work of the Department of Metallurgy, great changes took place and when the School of Mines found a home in the new building provided by Mr. Lewisohn, the excellent equipment of the laboratories and the part assigned to the different departments of metallurgy were due to the careful work and planning of Prof. Howe and his assistants. It was during this period also that much more attention was paid to the advantages of the metallurgical course and to establishing courses for the training of metallurgical engineers.

While these courses have been changed from time to time to suit conditions, the plans laid out by Prof. Howe were so well considered and have been of such value that in following them the work in the

department of metallurgy has steadily advanced in the right direction.

Prof. Howe comes from a very distinguished line, two of his ancestors having been governors of the American Colonies when they were under British rule. The sister of General Francis Marion was one of Prof. Howe's forbears, and Marion Crawford, the novelist, his first cousin. His father was the eminent philanthropist, Samuel G. Howe, M.D., LL.D., twice decorated for his philanthropic work. His wife, and Prof. Howe's mother, was the distinguished poet and philanthropist, Mrs. Julia Ward Howe, LL.D.

In 1874, Prof. Howe married Miss Fannie Gay, of Troy, N. Y. He was graduated from Harvard University as A.B., in 1869, from the Massachusetts Institute of Technology as B.S. in 1871, and a year later received the degree of Artium Magister from Harvard University. During the year 1871-2, he studied the process of manufacture of iron and steel in the field, in preparation for his professional work.

In 1872, he was appointed superintendent of the Bessemer steel works at Joliet, Ill., and from that time until 1883 was actively engaged in metallurgical manufacture. In 1891, in company with two others, he organized the Taylor Iron and Steel Company, now the Taylor-Wharton Iron and Steel Co., for the manufacture of manganese steel and other steel castings, projectiles, carwheels, and axles. He has been one of the directors of this company since that date, and has also for a number of years been one of its vice-presidents. In connection with this work he domesticated in this country the manufacture of manganese steel and of projectiles of various kinds.

In addition to his work in iron and steel he designed and built the extensive copper smelting works of the Orford Nickel and Copper Co. at Capelton and Eustis, in Canada, and at Bergen Point, New Jersey, in the United States. From 1889 to 1897, he was lecturer on metallurgy at the Massachusetts Institute of Technology in Boston. In 1897 he was appointed Professor of Metallurgy at Columbia University, and head of the department.

Prof. Howe is the author of many works on metallurgical subjects, among which the following may be mentioned: "The Metallurgy

of Steel," 1890, also published in French; "Copper Smelting," 1885; "Metallurgical Laboratory Notes," 1902, also published in French; "Iron, Steel and Other Alloys," 1903, also published in Russian. In addition he has published about 260 scientific papers and reports.

He was a member of the United States Assay Commission in 1887; of the Jury of Awards at the Paris Universal Expositions of 1889 and 1900; President of the Jury of Awards at the World's Columbian Exposition at Chicago in 1895; three times President of the Alumni Association of the Massachusetts Institute of Technology; President of the American Institute of Mining Engineers, 1893; President of the American Society for Testing Materials from 1900 to 1902, and again from 1909 to 1912; Acting President of the International Association for Testing Materials from 1902 to 1912, and then President and Life Member of Council of the International Association for Testing Materials in 1912.

Prof. Howe's great ability has been recognized all over the world and he has received many honorary degrees and special honors: Doctor of Laws from Harvard University and also from Lafayette College, 1905; Knight of the Order of St. Stanislas, of Russia, of 2d Order, with Star of 1st Order; Chevalier of the Legion d'Honneur of France; Bessemer Medallist of the British Iron and Steel Institute; Elliott Cresson Medallist, the highest honor of the Franklin Institute of Philadelphia; Gold Medallist of the Verein Beforderung des Gewerbfleisses, of Berlin, Germany, the highest honor this society can bestow on a foreigner. He is an honorary member in the following societies: Russian Imperial Technical; Russian Metallurgical; Royal Swedish Academy of Sciences; American Philosophical; Cleveland Institution of Engineers, England; Société d'Encouragement pour l'Industrie Nationale, of France; Dallas Historical Society, United States; Alumni Association of the School of Mines of Columbia University; and British Institute of Mining and Metallurgy.

Prof. Howe is an indefatigable worker; is at his desk from early in the morning till late in the afternoon for six days a week, Saturdays and most holidays included. For some years most of his energy has been put into the preparation of a new edition of his treatise

on the "Metallurgy of Steel," the first volume of which he expects to bring out this year. He has always felt that it was an inspiring privilege to help in developing the character of the young men of Columbia. But pleasant as this has been, prudence demands that it should be put aside in order that the task of harvesting the fruit of his life's experience may be of use to his successors, and this task needs uninterrupted labor. In closing this brief sketch, the writer desires to quote the words of the late Sir William Roberts-Austen, who in presenting the Bessemer Gold Medal to Professor Howe for his well-known treatise on steel, paid him the gracious tribute of saying that he "had done for the literature of metallurgy what his countrymen, Emerson, Hawthorne and Lowell had done for English literature generally; he had produced a work which might form a part of, and enter into the daily occupation of, their life."

ARTHUR L. WALKER.

A SCHEME FOR UTILIZING THE POLARIZING MICROSCOPE IN THE DETERMINATION OF MINERALS OF NON-METALLIC LUSTRE

BY A. J. MOSES.

Although numerous[1] "schemes" exist for the determination of the rock-forming minerals by the microscopic study of carefully prepared thin sections and a few schemes or tables in which either most minerals[2] or a selected series[3] of the more important are classified by their optical characters; the "schemes" by which a student with a few months' experience "determines" the identity of a larger or smaller series of the more common or important minerals rarely include the exact easily applied distinctions obtainable with the polarizing microscope, although this instrument is now in every mineralogical laboratory and in most well equipped chemical laboratories.

If the polarizing microscope is to be used in such work the tests must be *quickly* obtainable and accurate. The thin sections of the petrographer will not therefore be available, nor in general can those optical characters be made prominent which are only obtainable for some particular direction of transmission of light. In my opinion also, for this particular kind of scheme, the optical characters should be made subordinate to the very thoroughly worked out so-called "blowpipe tests" and "physical tests."

The only existing substitute for a "thin section" in microscopic study is a powder, in which the thickness of the grains is near the 0.03 to 0.04 mm. commonly used in the thin section. Powders have been microscopically studied for a considerable period, for instance

[1] Johannsen's "Key for the Determination of Rock-Forming Minerals in Thin Sections," John Wiley & Sons, 1908. Luquer's "Minerals in Rock Sections," D. Van Nostrand Co., 4th Ed., 1913.

[2] Winchell's "Elements of Optical Mineralogy," D. Van Nostrand Co., 1909. "Tabellen zur mikroskopischen Bestimmung der Mineralien," von J. L. C. Schroeder van der Kolk, 2nd Ed., Wiesbaden, 1906.

[3] "Determination of Minerals in Crushed Fragments by Means of the Polarizing Microscope," Austin F. Rogers, THE QUARTERLY, xxvii, p. 340.

in the examination of soils.[4] The late Dr. J. L. C. Schroeder van der Kolk developed a method for the determination of minerals and no criticism can be made of his "Tables"[5] except that their use requires rather the knowledge and skill of a post-graduate than of an undergraduate student.

A very interesting paper was published[6] in 1905 by Dr. Austin F. Rogers, then Instructor in Mineralogy at Columbia University, which describes a simple method of crushing and sieving by which fragments can be obtained which in their tendency to definite orientation are much more satisfactory than haphazard thin sections. For example he states that "in ten fragments of hornblende the extinction angles varied only from 15½° to 17½°." The paper records observations on about 125 species and tabulates the results under headings based on the "shape" of the crushed fragments. This classification has not seemed to me a practical one.

The scheme here printed is practically a modification or extension of my older scheme, printed in THE QUARTERLY, Vol. 21 p. 192. Thirty-four divisions are obtained by four tests: "Taste"; "Behavior on Charcoal with Soda"; "Heating in Platinum Forceps"; and "Boiling in Dilute Hydrochloric Acid. The method is indicated by the Key, p. 315. These 34 divisions are then subdivided by two tests with the polarizing microscope.

(1) The relative indices of the powder and four chosen mounting liquids.

(2) The birefringence of the powder expressed in five terms determined by the interference colors.

Other notable characters are given in parallel columns. For convenience the tests used are described in the order of testing.

ORDER OF TESTING.

1. Taste. 2. Treatment on Charcoal with Soda. 3. Treatment in platinum forceps. 4. Solubility in dilute hydrochloric acid. 5. Crushing and mounting. 6. Microscopic study, as follows:

(*a*) *Examination with both Nicols out:*

Shape; Color; Inclusions.

[4] "Anleitung zur Mineralogischen Bodenanalyse," Dr. Franz Steinriede, Leipzig, 1889.

[5] Last cit.

[6] SCHOOL OF MINES QUARTERLY, April 1906, p. 340.

(*b*) *Examination with upper Nicol out:*
Indices of Refraction; Pleochroism.
(*c*) *Examination with crossed Nicols and parallel light:*
Extinction; Birefringence; Elongation.
(*d*) *Examination with crossed Nicols and convergent light:*
Interference Figure; Optical Sign.

"Taste" or Solubility in Water.— It is not supposed that each specimen will be tasted, or even tested for solubility in water. The test can be omitted entirely if the minerals is above 3 in hardness, and in addition very few minerals soluble in water fail to show this if exposed to air, becoming damp, pulverulent or dull.

If the test is made the existence of a "taste" is unmistakable, but the recognition of the taste is not easy. I have therefore introduced in this division the *Recrystallization Tests* of Rogers, of which he says: "For minerals soluble in water, the best and simplest method is to recrystallize from water by allowing several drops of the solution to evaporate in the air on a glass slip. The recrystallized product is very characteristic, either being the original substance or different substances."

Treatment on Charcoal with Soda.— This is practically Test II of my scheme for blowpipe analysis[7] and may at pleasure be elaborated, as in that scheme, to determine some eighteen elements.

Treatment in Platinum Forceps.— This is the usual "fusion test."[8] The scheme and the safety of the forceps both require that the absence of volatile or easily fusible elements should first be proved on charcoal. Sharp edged thin fragments long enough to project beyond the platinum must be used and the fragments *for any comparison* should be approximately of the same size and shape. The dividing line between "fusible easily" and "fusible with difficulty" is pure white orthoclase which would be called "fusible with difficulty."

Solubility in Dilute Hydrochloric Acid.— This test fails only from carelessness. The substance must be picked as nearly pure as possible, finely ground and added in successive small quantities

[7] "Elements of Mineralogy, Crystallography and Blowpipe Analysis," p. 117. 1911 Ed.
[8] *Ibid*, p. 82.

to the acid. The heating must be gradual, and if doubt exists as to solubility *the liquid must be filtered and evaporated to dryness,* a residue proving solution to have taken place.

Crushing and Mounting.— A small fragment is crushed either by pressure in a small agate mortar or by pounding on a small steel plate with a blowpipe hammer or by rolling an agate cylinder on a steel or agate plate. Grinding is to be avoided, as the sharp cleavages are injured and the smaller adhering particles confuse the effects yielded by the larger ones. The crushed material is then sieved through a little 100-mesh screen and, falling upon a 120-mesh screen, the finer portion penetrates that. The particles remaining on the 120-mesh screen are then shaken out on a clean paper and used in making the slides.

A few fragments are placed on an object glass (Wright advises a little platinum spatula made by hammering flat the end of a 1-mm. thick platinum wire). A drop of the liquid is placed *to one side* so as not to contaminate the dropper; the powder is then drawn into the liquid by the tilted cover slip which is then placed in position.

It is recommended that *α* monobromnapthalin be used first because it is colorless, not too volatile, and of a middle index of refraction.

Tests With Both Nicols Out.

Shape.— Because crushing tends to develop the cleavages, and because the fragments tend to lie on the broadest cleavage surface, there is some constancy in shape among crushed fragments of each mineral. Cleavage is proved by the existence of parallel straight-line boundaries or cracks. These, according to the number and relative directions of the systems of parallels, give rise to shapes which I have designated as "laths," "needles," "fibres," "triangles," "rhombs," "rectangles," and "plates" (*flat* particles lacking straight edge boundaries). In absence of any proof of cleavage, the fragment is called "irregular."

Color by Transmitted Light.— Most minerals, even if colored in mass, appear colorless in crushed fragments; some are nearly the color of the mass, some are a lighter tint, and some a totally dif-

ferent color. If no color is given in the scheme, the fragments are colorless.

Indices of Refraction may be determined here, but are usually determined with the lower nicol in.

Inclusions are best observed with the condensing lens in. Their arrangement, oclor and shape should be noted.

TESTS WITH POLARIZING NICOL (UPPER NICOL OUT.)

Indices of Refraction.— In any doubly refracting mineral fragment, the refractive indices vary with the direction of vibration of the light rays. The scheme considers only the indices of refraction corresponding to the two positions of extinction (see p. 311) in the fragment. The problem is to determine whether, for either one (or better for both) [9] of these positions, the refractive index of the grain is greater than, or less than, that of the liquid. Two methods are used, called respectively "The Becke Test" and "The van der Kolk Test."

The Becke Test.[10]— This test can usually be made with moderate power objective upon a fragment with an approximately vertical boundary or edge. The best results are obtained with a high-power objective and a light stop below the stage. It is based upon the principle of total reflection.

With both nicols in, the stage is revolved until the grain is black. The upper nicol is then drawn out, the condensing lens, and lower nicol, lowered so as to prevent the entrance of strongly divergent rays, and the microscope is sharply focused upon the vertical boundary by the fine adjustment. If the objective is now raised slightly, a line of light, parallel to the boundary, will appear *to move into the substance* which has the higher index. By lowering the objective the white line is moved in the opposite direction.

By using a series of liquids, one can be found in which a color-

[9] If the index of the liquid lies between the indices obtained for the two extinction directions (in which case for some intermediate position of the grain the outline will nearly disappear) the name of the mineral will appear in two divisions.

[10] Becke, *Sitz. der k. k. Akad. d. Wiss. Wien.*, I. Abt., p. 358, 1893. Luquer, "Minerals in Rock Sections," 2d Ed., 1905.

less fragment is practically invisible, and no line is noticed. The liquids used in this scheme are:

	Index at 15°C.	*Specific Gravity.*
Xylol	1,487	0.87
Bromoform	1,590	2.84
αMonobrom napthalin	1.655	1.50
Methylene Iodide	1.740	3.31

Van der Kolk,[11] however, gives a list of about fifty, ranging from 1.33 to 1.93, and Wright [12] gives a list ranging from 1.450 to 2.750, prepared chiefly from mixtures of a comparatively small number of liquids.

The van der Kolk Test.[13]— This test requires a medium power objective, a condensing lens and preferably a fragment with tapering edges. It is based upon the fact that such a fragment acts like a lens on the obliquely incident light.

With both nicols in, revolve the stage until the grain is dark. Then, with the upper nicol out and the grain in focus, slide a sharp edged card below the lower nicol, drop the condenser until the edge of the card is sharply focused, *then drop a little further.* Move the card slowly toward the grain and notice *which side of the grain becomes the brighter.*

Bright side of grain towards card — Index grain > Index liquid.

Bright side of grain away from card — Index grain < Index liquid.

If the index of the grain is just that of the card for, say, yellow light, the grain will be bordered by red on the side near the card and blue on the opposite side.

Absorption and Pleochroism.— With upper nicol out note the change of color on rotation of stage. Record the colors for the positions of extinction. (See below).

The changes in intensity without change of color, usually called absorption, are included here.

[11] Last cit, p. 12.

[12] "Methods of Petrographic Microscopic Research," F. E. Wright, Carnegie Inst., 1911, p. 98.

[13] "Tabellen zur mikros. Best. d. Min.," 2nd Ed., p. 3. Also *American Journ. Science*, May, 1906, v. 21, p. 362 (Wright).

Tests With Crossed Nicols.

Extinction and Extinction Angles.— The four positions of darkness, 90° apart, are the two so-called extinction positions. The angle that is turned from either of these until a recognizable crystalline direction (cleavage, outline, twin plane, etc.) coincides with one of the properly adjusted cross hairs of the microscope is called an extinction angle. In crushed fragments, because of the tendency of the grains to constant shape and orientation, more constant angles result than in rock sections. The crystallographic direction chosen is usually a straight edge due to cleavage.

Manipulation.— Focus with the upper nicol out, make the edge coincide with a cross hair, read the vernier, push in the upper nicol, rotate the stage until the field is dark, again read the vernier. The difference between the two readings is the extinction angle with the chosen edge.

The method of designating here used is:

Ex. || when the angle turned is zero.

Ex., Sym. when the angle turned is one-half the angle between two crystalline directions.

Ex., Obl. when the extinction is neither "parallel" nor "symmetrical," or the angle may be stated, E. g., Ex. 27°.

Birefringence.— (*a*) *Direct Determination.*— The birefringence, or strength of double refraction, *for the particular grain* is the difference between the indices of refraction of the two rays with vibrations in the positions of extinction. It can be numerically determined with considerable accuracy by the use of a series of liquids and the separate determination of the two indices.

(*b*) *Approximate determination by Interference Colors.*— The method here followed is simple. It is assumed that the thickness of the average fragment is .03 to .04 mm. Such grains will show, between crossed nicols, interference colors dependent almost entirely on the birefringence (as defined above) of the grain. The birefringence may therefore be stated in terms of color; I have used five such terms.

In testing, two so-called "test-plates" are used, which will be briefly referred to as the Mica plate and the Gypsum plate. The

grain is focused, the upper nicol pushed in. If the grain transmits light, an extinction position is found, and the stage revolved 45° further, to the position of brightest illumination. The test-plate is inserted, as needed, between the nicols in the slot provided, and the changes noted.

QUARTER UNDULATION MICA PLATE.— A thin sheet of mica on which is marked c, the vibration direction of the ray with the larger index of refraction. The thickness chosen corresponds to 140 $\mu\mu$ or $\frac{1}{4}$ wave length for a medium yellow light.

GYPSUM RED OF FIRST ORDER.— A thin cleavage of gypsum which is similarly marked. The thickness chosen corresponds to an interference color of red of first order, or 560 $\mu\mu$.

The test-plates "raise" or "lower" the interference colors due to the fragment according as the corresponding extinction directions in plate and fragment are parallel or crossed. The terms of color, the equivalent birefringences for a thickness 0.035 mm, and the detail, or effect, of the test-plates may be stated as follows:

Term of Color	*Detail*	*Equivalent Birefringence*
BLACK	Unchanged by rotation:	0.
GRAY OR WHITE	By gypsum plate made yellow for crossed position, blue or purple for parallel position	<0.008
BRIGHT A.	By gypsum plate made white or gray or black for crossed position	0.008 to 0.024
BRIGHT B.	By gypsum plate bright colors *for both positions.* By mica plate *notably* different tints for crossed and parallel positions.	0.024 to 0.06
HIGH ORDER.	Not describably affected by mica plate in either position.	>0.06

The term "Bright" signifies definite, brilliant colors. "High order" signifies faint varied tints not easily distinguished, and grading into white. Bright A are the lower-order bright colors reducible to whites, etc., by the gypsum plate.

Elongation.— The fragments obtained by crushing are often shaped like laths, needles, fibres, etc. The longer direction or "Elongation" is usually a crystallographic direction. It is therefore possible to use it as a character in the following manner:

The fragment is revolved 45° from that extinction position *which is nearest* the *"elongation."* The interference color is noted. The

test plates already described are then successively inserted with c parallel to this diagonal position. The changes in color *and the moving in or out of the color bands* along the periphery of the fragment are noted. The record is

El., (+) when color bands MOVE OUT and colors become HIGHER.

El., (−) when color bands MOVE IN and colors become LOWER.

Naturally with c in crossed position the effects reverse.

A very gradually tapering quartz wedge is even better for this test.

TESTS WITH CROSSED NICOLS AND CONVERGENT LIGHT.

Interference Figure.— This test is obtained with the polarizing microscope by using a high power objective and a convergent lens directly under the stage. The section is focused with the upper nicol out, then this is pushed in, the eye piece removed, and the interference figure viewed by looking down the tube. For micaceous minerals, and some other minerals which cleave to the proper section, this test is readily obtainable in crushed fragments. The interference figures can not be here discussed in detail but for convenience the following facts are stated:

Isometric Crystals yield no interference figure. All fragments will remain dark whatever the position of the fragment, both in convergent and polarized light.

Tetragonal and Hexagonal (Uniaxial) Crystals.— In fragments at right angles to the vertical axis, and which with parallel light remain dark during rotation, there will always appear a dark cross, the arms of which intersect in the center of the field, and remain parallel to the vibration directions of the nicols during rotation of the fragment. If interference colors show,[14] they will occur in circles around the center of the black cross.

Orthorhombic, Monoclinic and Triclinic (Biaxial) Crystals.— From certain fragments technically spoken as "normal to the acute bisectrix,"[15] there is obtained, in two positions 90° apart, a black cross one arm of which is usually sharper and more distinct

[14] In fragments of the same mineral, the thicker the section the closer the rings, while in fragments of different minerals but equal thickness, the greater the value of the birefringence, the closer the rings.

[15] The acute bisectrix is often a crystal axis but not necessarily. It bisects the smaller angle between the optic axes.

than the other. If the section is turned, the dark lines seem to dissolve into hyperbolæ, the branches of which rotate in the opposite direction to the rotation of the stage and the convex side of each is always toward the other branch. If any color is shown it is in curves around two points through which the sharper arm of the cross passes. These curves are not circles, and there is no change in shape during rotation of the stage. Sometimes even the first ring will surround both axes.

The Optical Sign.— The unaxial interference figure and the biaxial figure for small or moderate angles is broken up by the mica plate differently in different crystals. The effects in so-called "positive" and "negative" crystals suggest the corresponding signs + and – by the relative positions of the dark flecks near the center and the arrow showing the direction c of the test plate. If the distance between the axial points is large (that is, the "angle" is large), the interference figure is placed in diagonal position, and a quartz wedge is gradually inserted with the direction c parallel to this line. If the crystal is *positive* the rings around each axis will *expand,* moving toward the center and corresponding rings will merge in one curve. If the crystal is *negative* the rings will *contract* and increase in number, the change increasing with the thickness of wedge interposed.

Index Refraction Sign and Birefringence.— I have recorded for each mineral the "Index-Sign" and "Birefringence." It is understood that these simply show the extreme values (obtainable for instance in a uniaxical mineral from a section parallel to the vertical axis). The indices of every fragment will necessarily fall *within* these limits.

Following Van der Kolk, I have avoided the socalled "mean index" [16] so generally used in petrographic work and have recorded:[17]

[16] $\frac{\alpha + \beta + \gamma}{3}$ for biaxial, $\frac{2\omega + \epsilon}{3}$ for uniaxial,

[17] The practical reason is that in uniaxial crystals *every* fragment gives for one of its extinction directions the value ω, while the other extinction direction yields different values for different grains. Many biaxial crystals approach determination of the exact index, there is the further reason that the red and nearly the part of the ordinary index. In van der Kolk's work, which involves the uniaxial, two of the principal indices being nearly the same. These play blue borders which then show are more distinct for the directions chosen than for the other.

For uniaxial crystals, ω, the index of the ordinary ray.

For positive biaxial crystal, α, the smallest index.

For negative biaxial crystals, γ, the largest index.

The other extreme index results by adding or subtracting the birefringence, according as the sign is (+) or (−).

KEY TO MINERALS OF NON-METALLIC LUSTRE.

A. Minerals with Decided Taste	Which Color the Flame.			1	
	Which do not Color the Flame.			2	
		WITH HYDROCHLORIC ACID:			
		Effervesces	Forms Jelly.	Dissolves only.	Is Insoluble.
B. Tasteless, but with Soda on Charcoal in the Reducing flame Yields:	Arsenical Odor.			3	4
	Fumes and a Metallic Globule.	5		6	7
	Fumes but not a Metallic Globule.	8	9	10	11
	No Fumes but Magnetic Residue.	12		13	
C. Neither A nor B but heated in Pt. Forceps:	Fuses Easily to a White Glass or Enamel.	14	15	16	17
	Fuses Easily to a Colorless Glass.		18	19	20
	Fuses Easily to Colored Glass or Enamel.	21	22	23	24
	Fuses with More Difficulty Than Common Orthoclase.	25	26	27	28
	Is Infusible but in Powder Made Deep Blue by Cobalt Solution.			29	30
	Is Infusible, not Made Deep Blue by Cobalt Solution.	31	32	33	34

Conventions and Abbreviations.

The system of crystallization is indicated by the letters I. T. O. M. Tri H, and Amorphous by A.

Ex., ∥; Ex., Obl.; Ex., 22°; Ex., Sym., denote that the extinction is respectively parallel, oblique, at angle of 22°, and symmetrical.

El., (+); El., (−), denote that the elongation is (+) or (−).

Other abbreviations less used are:

Fl=flame.
Ts.=taste.
Obl.=oblique.
Unsym.=unsymmetrical.
Co. Sol.=cobalt solution.
B. B.=before the blowpipe.
Cl. Ang.=cleavage angle.
H.=hardness.
G.=specific gravity.
Rectang.=rectangular.

1.

CRUSHED FRAGMENTS.			Crystal System, **Name**, Composition.	NOTABLE MINERAL CHARACTERS.	
Index of Refraction.	Interference Color.	Recrystallization in a Drop of Water.		Appearance or Tests.	Index Refr. Sign and Birefringence.
< Xylol.	Black.	Isotropic octahedra and branching.	I. **Kalinite**, $KAl(SO_4)_2+12H_2O$	White efflorescence. Ts., astringent. Fl., violet.	1.46 0.0
	Gray or White Aggregate.	Unsym. polygons. Ex., ‖. and Obl.	M. **Borax**, $Na_2B_4O_7+10H_2O$	Snow white crystals or crusts. Ts., alkaline. Fl., yellow.	1.47(—).02
	Gray or White to Bright A.	Six sided plates and threads.	Tri. **Sassolite**, H_3BO_3	White pearly scales. Ts., acid. Fl., yell. green.	1.46(—) †
	Bright A.	Isotropic rectangles and needles crossed obliquely.	M. **Kainite**, $MgSO_4KCl+3H_2O$	White to red granular. Ts., salt. Fl., violet.	1.47(—).01
	Bright A.	Rectangles. Ex., Obl. or Isotropic.	O. **Carnallite**, $KCl.MgCl.6H_2O$	Deliquescent red or white. Co. Sol., pink. Fl., violet.	1.47(—).01
	Bright A.	Laths. Ex., ‖.	O. Thenardite, Na_2SO_4	Crossed and simple crystals. Ts., salt. Fl., yellow.	1.47(—).02
			Nitre and Soda Nitre	See under Xylol.	
= Xylol.	Black.	Cubes and isotropic aggregates.	I. Sylvite KCl	Cubooctahedra. Masses. Ts., salt. Fl., violet.	1.49 0.0
	Black.	Cubes. Isotropic.	I. **Halite**, NaCl	White or brown. Cubic cleavage. Ts., salt. Fl., yellow.	1.54 0.0
	Low.	Rectang. laths and branching. Ex., ‖.	H. Aphthitalite $(KNa)_2\ SO_4$	On lava Ts., bitter. Fl., violet.	1.49(+).01
> Xylol.	Gray or White.	Spherulitic aggregates.	M. Trona, $Na_2CO_3.NaHCO_3+2H_2O$	White crusts. Ts., alkaline. Fl., yellow.	1.50(—) †
	Gray or White.	Laths. Ex., ‖.	M. Mirabilite, $Na_2SO_4+10H_2O$	White efflorescence Ts., bitter. Fl., yellow	1.52 †
	Bright A.	Blue crystals. Ex., Obl.	Tri. Chalcanthite, $CuSO_4+5H_2O$	Pale blue crystals or crusts Ts., nauseous. Fl., deep green	1.55(—).03
	High Order.	Laths Ex., ‖. Aggregates.	O. **Nitre**, KNO_3	Needles or crusts. Ts., cooling. Fl., violet.	1.51(—).17
	High Order.	Rhombs. Ex., Sym.	H. **Soda Nitre**, $NaNO_3$	Deliquescent granular. Ts., cooling. Fl., yellow.	1.58(—).25

2.

< Xylol.	Gray or White. Aggregate.	Laths. Ex., ‖.	O. Epsomite, $MgSO_4+7H_2O$	White fibres or crusts. Ts., bitter. Co. Sol., pink.	1.46(—).03
	Gray or White.	Branching aggregates.	M. Melanterite, $FeSO_4+7H_2O$	Pale green to white. B.B. Magnetic. Ts., astringent.	1.48(+).02
	Gray or White.	Feathery. Ex., ‖.	M. Alunogen, $Al_2(SO_4)_3+18H_2O$	White fibres or crusts. Ts., astringent. Co. Sol., blue.	?
	Aggregate.	Radiating needles, Ex., ‖.	O. Goslarite, $ZnSO_4+7H_2O$	White. B.B., white coat. Ts., nauseous.	1.48(—).02
> Xylol.	Black.	Aggregates branching at 60° and 90°. Isotropic.	I. Sal Ammoniac, NH_4Cl	White crusts. Ts., sharp biting. B.B. white fumes.	1.64 0.0
	Bright B.	No recrystallization observed.	M. **Copiapite**, $Fe_2Fe(OH)_2(SO_4)_3\cdot 18H_2O$	Yellow scales or granular. B.B., magnetic. Ts., nauseous.	1.57(—).05

3.

CRUSHED FRAGMENTS.			Crystal System, Name, Composition.	NOTABLE MINERAL CHARACTERS.	
Index of Refraction.	Interference Color.	Other Notable Characters.		Appearance or Tests.	Index Refr. Sign and Birefringence.
< Methylene Iodide.	Aggregate.	Greenish hairs or aggregate.	M. Annabergite, $Ni_3(AsO_4)_2+8H_2O$	Apple green crusts or fibers. Tests. As. Ni	1.68(—).05
	Bright B.	Laths Pleochroic pink to red. Ex., Obl.	M. Erythrite, $Co_3(AsO_4)_2+8H_2O$	Crimson fibers and prisms. Tests. As. Co.	1.68(—).05
> Methylene Iodide.	Gray or White to Bright A.	Colorless, greenish. Irregular.	H. Mimetite, $Pb_5Cl(AsO_4)_3$	Prisms or globular groups. Tests. As. Pb.	2.13(—).02
	Bright B.	Green to yellow. Irregular.	O. Olivenite, $Cu_2(OH)AsO_4$	Olive green to brown crystals and fibers. Tests. As. Cu.	1.83(+)>.03

4.

> Methylene Iodide.	Bright B. or masked.	Yellow Laths or Irregular	O. **Orpiment**, As_2S_3	Cleavable or fine grained. Color and streak lemon yellow.	?(+).04
	Bright B. or masked.	Yellow to orange. Irregular	M. **Realgar**, AsS	Translucent red crystals and masses Streak orange red.	>1.75(—).03
	Masked.	Brownish orange. Irregular.	H. **Proustite**, Ag_3AsS_3	Color and streak scarlet vermilion. Lustre adamantine. Test Ag.	2.94(—).17

5.

> Methylene Iodide.	Bright A to B.	Rectangular. Ex., ‖, El., (+),	T. Phosgenite, $(PbCl)_2CO_3$	Transparent, colorless. White coat on charcoal.	>1.93(+).03
	High Order.	Irregular.	O. **Cerussite**, $PbCO_3$	Fibrous, silky, compact. Yellow coat on charcoal.	2.07(—).27
?	?		— Bismutite, $(BiO)_2CO_3$	Incrustation or earthy. Nearly white. Water gives white precipitate from HCl.	?

6.

	Black.	Irregular.	I. Senarmonite, Sb_2O_3	Pearl gray octahedrons. Test. Sb.	2. 0.0
	Gray or White to Bright A.	Colorless to green. Irregular.	H. **Pyromorphite**, $Pb_3Cl(PO_4)_3$	Green or brown prisms, often parallel. B.B. Fuses, recrystallizes. Test Pb.	2.05(—).01
	Bright B.	Needles. Ex., ‖.	O. Valentinite, Sb_2O_3	White silky prisms or fibers. Test. Sb.	2.34(—).05
	Bright B.	Deep yellow to orange. Irregular or Laths	H. **Vanadinite**, $Pb_3Cl(VO_4)_3$	Red and brown prisms often hollow. Tests Pb. V.	2.85(—).05
> Methylene Iodide.	Bright B.	Brown to greenish. Irregular.	O. Descloizite, $(Pb,Zn)(PbOH)VO_4$	Black, brown or red crusts of crystals. Tests Pb. Zn. V.	1.83 Strong
	Bright B.	Pleochroic, yellow to orange. Irregular.	M. Crocoite, $PbCrO_4$	Hyacinth red crystals, orange streak. Tests Pb. Cr.	2.42(+).05
	High Order.	Yellow. Irregular.	T. **Wulfenite**, $PbMoO_4$	Yellow or brown square plates or pyramids. Tests Pb. Mo.	2.40(—).10
	Masked.	Pleochroic, ruby red needles. Ex., ‖.	M. Kermesite, Sb_2S_2O	Cherry red tufts or fibers. Tests Sb.	?
	?	?	— Minium, Pb_3O_4	Vivid red. Pulverulent. Test Pb.	?
	?	?	— Bismite, Bi_2O_3	Yellow to white powder. Test Be.	?

7.

			Fused in Tube with $KHSO_4$	**Sectile, Wax-Like**	
	Black.	Irregular.	I. **Cerargyrite**, AgCl Globule, yellow hot, white cold.	Pearl gray, greenish. Darkens.	2.06 0.0
	Black.	Greenish. Irregular.	I. Embolite, Ag(ClBr)	Yellow to green. Darkens.	? 0.0
	Black.	Irregular.	I. Bromyrite, AgBr Globule red hot, yellow cold.	Green. Little changed by sun.	2.25 0.0
> Methylene Iodide.	Black.	Yellowish. Irregular.	H. Iodyrite, AgI Violet vapor, globule dark red.	Yellow. Unchanged by sun. (All give silver buttons.)	2.18(+) ?
	Gray or White to Bright A.	Irregular	O. **Anglesite**, $PbSO_4$	Colorless to white crystals or massive.	1.88(+).02
	Bright B.	Blue Laths. Ex., ‖.	M. Linarite, $[(PbCu)OH]_2SO_4$	Deep blue crystals.	1.86(—).05
	High.	Colorless to pleochroic yellow. Irregular.	T. **Cassiterite**, SnO_2	Yellow to brownish-black. Adamantine crystals or dull pebbles.	2.09(+).09
	Masked.	Dark red. Irregular.	H. **Pyrargyrite**, Ag_3SbS_3	Color nearly black, streak purplish red. Lustre adamantine. Ag test.	3.08(—).20

8.

CRUSHED FRAGMENTS.			Crystal System, Name, Composition.	NOTABLE MINERAL CHARACTERS.	
Index of Refraction.	Interference Color.	Other Notable Characters.		Appearance or Tests.	Index Refr. Sign and Birefringence.
<αMono-brom-Napthalin.	Black or Bright A.	Irregular or Laths with Ex., ‖. El. (+).	—. Hydrozincite, $Zn_5CO_3(OH)_6$	H. 2 to 2.5. Chalk-like or in dazzling white crusts. Water test.	>1.59 <1.65 weak
>αMono-brom-Napthalin.	Black.	Yellow. Cleav. lines at 60°, 90°, 120°.	I. **Sphalerite**, ZnS	Brown to black resinous crystals or cleavable or grayish masses. Gives H_2S.	2.37 0.0
	↑	Yellow.	H. Greenockite, CdS	Yellow crust or coloration usually on Sphalerite or Smithsonite. Brown coat and iridescent tarnish on coal.	2.69(+) weak
	High Order.	Rhombs. Ex., Sym. or Irregular.	H. **Smithsonite**, $ZnCO_3$	H. 5. Vitreous, botryoidal, white to brown or porous. Often incrusting.	1.82(—).20

9.

<αMono-brom-Napthalin.	Bright B.	Laths. Ex., ‖. El. (+).	O. **Calamine**, $(ZnOH)_2SiO_3$	White to brown vitreous with crystal surface. Water in closed tube.	1.62(+).03
>αMono-brom-Napthalin.	Bright A to B.	Colorless to brown. Irregular.	H. **Willemite**, Zn_2SiO_4	Yellow to green or brownish resinous masses. Coarse crystals.	1.70(+).02

10.

>Methyl-ene Iodide.	Masked.	Yellow to orange.	H. **Zincite**, ZnO	Dark red, cleavable or grains. Orange streak.	2. (+).02
	↑	Minute needles, Ex., ‖.	O. Molybdite, MoO_3	Yellow powder.	1.83(+).20

11.

> Methylene Iodide.	Masked.	Brilliant red. Irregular.	H. **Cinnabar**, HgS	Vermillion to scarlet masses or crystals. Scarlet streak.	2.85(+).35
	High Order.	Rhombs, rectangles and irregular.	T. Calomel, Hg_2Cl_2	Colorless with horn-like lustre and consistency.	2.31(+).68
	High Order.	Irregular.	O. **Sulphur**, S	Translucent, yellow, resinous. Burns with blue flame and odor SO_2.	1.95(+).29

12.

> Methylene Iodide.	High Order.	Rhombs. Ex., Sym. Index short diag. = 1.73. (Closely methylene iodide.)	H. **Siderite**, $FeCO_3$	Brown. Cleavable to rhombohedron 107°. Granular or curved rhombohedra.	Near 1.93(—).20

13.

< Methylene Iodide.	Gray or White. Aggregate.	Greenish. Irregular.	—. **Garnierite**, $H_2(Ni,Mg)SiO_4+H_2O$	Deep green to pale green. Soft and friable.	1.59
	Bright B.	Pleochroic blues or colorless. Plates and Laths. Ex., ‖. El., (+) or Ex., 30° El., (—).	M. Vivianite, $Fe_3(PO_4)_2+8H_2O$	Colorless to dark blue with blue streak. Often earthy.	1.58(+).05
			Streak yellow to brown.		
> Methylene Iodide.	Bright B.	Yellow fibres, Ex., Obl., and opaque, irregular.	—. **Limonite**, $Fe_2O_3.Fe_2(OH)_6$	Earthy to compact or fibrous. Lustre dull to varnish-like.	>1.93(+).04
	High Order.	Pleochroic yellow Laths Ex., ‖.	O. Goethite, FeO(OH)	Needles, scales and velvet crusts, or parallel groups of plate-like crystals.	2.5(—).08
			Streak Red.		
	?	Opaque. Irregular.	Turgite, $Fe_4O_5(OH)_2$	Blackish crusts. In closed tube flies to pieces.	
	Masked.	Dark red or opaque.	H. **Hematite**, Fe_2O_3	Dull red to brilliant black often scales or crystals. In closed tube unchanged.	2.96(—).25

14.

CRUSHED FRAGMENTS.			Crystal System, Name, Composition.	NOTABLE MINERAL CHARACTERS.	
Index of Refraction.	Interference Color.	Other Notable Characters.		Appearance or Tests.	Index Refr. Sign and Birefringence.
<Bromoform.	Bright. A.	Plates or Laths Ex., ∥.	H. Cancrinite, $R(Na_2CO_3)(SiO_4)$ Witherite see below.	Yellow to white massive. Forms a jelly on heating.	1.51(—).03
>Bromoform.	High Order.	Plates or Laths. Ex., ∥, El., (—).	O. **Witherite**, $BaCO_3$	Heavy white, vitreous, Pseudo-hexagonal. Fl., yellowish green.	1.68(—).15

15.

<Bromoform.	Black.	Blue included particles.	I. Lazurite, $Na_4(NaS_2Al)Al_3(SiO_4)_3$	Intumesces. Massive. Deep blue color.	1.50
	Gray or White.	Rectangular. Ex., ∥ or isotropic.	T. **Apophyllite**, $H_{14}K_2Ca_8(SiO_3)_{16}9H_2O$	Nearly cubic or pyramidal. Opalescent ∥ vertical axis. Swells. Fl., violet.	1.53(+).002
	Gray or White.	Rhombs and Laths. Ex., Sym.	H. **Chabazite**, $(CaNa_2)Al(SiO_4)_3 6H_2O$	Rhombohedra (near cubes). Intumesces.	1.49(—).002
	Gray or White to Bright A.	Laths. Ex., ∥.	O. Thomsonite, $(Na_2Ca)Al_2Si_2O_8$	Radiating needles or compact with radiating structure.	1.52(+),02
>Bromoform.	Gray or White.	Laths or Needles. Ex., ∥.	M. **Wollastonite**, $CaSiO_3$	White compact to fibrous. Fl., red.	1.63(—).014
	Bright. A.	Needles. Ex., ∥. El., (+).	M. Pectolite, $HNa_2Ca(SiO_3)_3$	White. Radiating splintery fibers. Fl., yellow.	1.60(+).04

16.

< Xylol.	Black.	Polygons 3, 4, 5 or 6 sided, angles 60° and 120°.	I. **Fluorite**, CaF_2	Colorless or brightly colored cubes. Cleavage octahedral. Fl., red.	1.43 0.0
	Gray or White.	Roughly rectangular. Ex., Obl. large angle.	M. **Cryolite**, $AlNa_3F_6$	Translucent wax-like. White or brown. Fl., yellow. H=2.5.	1.34(+) weak
> Xylol.	Gray or White.	Laths. Ex., ‖. El., (—) or Ex., 25° to 30°.	M. Heulandite, $H_4CaAl_2(SiO_3)_6+3H_2O$	Pearly face less symmetrical than stilbite. Swells with heat.	1.50(—).007
	Gray or White to Bright A.	Rhombic Laths and Fibres. Ex., Obl.	M. **Gypsum**, $CaSO_4+2H_2O$	Soft white or tinted masses and crystals. Fl., red. Tests $H_2O.S.$	1.52(+).01
< Bromoform.	Gray or White to Bright A.	Laths. Ex., ‖. El., (—).	M. **Stilbite**, $H_4R_2Al_2(SiO_3)_6+4H_2O$	Sheaf-like groups and symmetrical pearly face. Swells with heat.	1.50(—).008
	Bright B.	Rectangular. Ex., ‖.	O. **Anhydrite**, $CaSO_4$	Fine grained or cleavable to cubes. Fl., red.	1.57(+).04
	Bright B or High Order.	Laths. Ex., ‖. El., (—). Inclusions.	T. **Wernerite**, CaNaAl silicate	Coarse dull crystals. Subfibrous cleavages. Fl., yellow.	1.57(—).025
> Bromoform.	Bright. A.	Laths. Ex., ‖. El., (—).	O. **Prehnite**, $H_2Ca_2Al_2(SiO_4)_3$	Crusts, smooth or drusy. Usually green. H=6 to 6.5.	1.62(+).03
	Bright. A.	Irregular.	Boracite, $Mg_7Cl_2B_{12}O_{30}$	Glassy pseudo isometric crystals H=7. Green flame. Co. Sol. violet.	1.66+.01
	Bright B.		Anhydrite	See above.	

17.

CRUSHED FRAGMENTS.			Crystal System, Name, Composition.	NOTABLE MINERAL CHARACTERS.	
Index of Refraction.	Interference Color.	Other Notable Characters.		Appearance or Tests.	Index Refr. Sign and Birefringence.
<Bromoform.	Gray or White to Bright A.	Plates and Laths. Twinning.	Tri. **Plagioclase,**	Fl., yellow. H=6. Cl. Ang. 86°.	
		Ex., 4° on 001, 19½ on 010.	Albite, $NaAlSi_3O_8$	White, granular, cleavable curved surfaces.	1.53(+).01
		Ex., 0° to 2° on 001, 0° to 15° on 010.	Oligoclase, $n(NaAlSi_3O_8).(CaAl_2Si_2O_8)$	Whitish. Broad striated cleavages.	1.55(—).01
		Irregular.	M. Petalite, $AlLi(Si_2O_5)_2$	White granular, cleavable. Fl., red. B.B. phosphoresces.	1.50(+).01
	Bright A to B.	Plates.	Tri. Amblygonite, $Li(AlF)PO_4$	White, cleavable. G. 3. Fl., red. B.B. intumesces.	1.59(—).02
>Bromoform.	Gray or White to Bright A.	Rectangular, Ex., ‖; or rhombic, Ex. Sym.; or irregular.	O. **Celestite,** $SrSO_4$	White, pale blue. Cleavable. Fl., crimson. G.=3.9.	1.62(+).01
		Like celestite.	O. **Barite,** $BaSO_4$	White cleavable, granular. Fl., pale green, G=4.3.	1.64(+).01
<α-Monobrom-Naphthalin.		Plates and Rhombs. Biax. Int. Fig.	M. Lepidolite, $R_3Al(SiO_3)_3$	Pink to white masses of fine scales. Fl., red.	1.60(—).03
				White fibrous or crystals.	1.63(—).03
		Laths or fibres. Cross cracks. Ex. 18° El. (+).	M. **Amphibole,** (Tremolite), $CaMg_3Si_4O_{12}$	Brown hemimorphic crystals. Fl., bright green. H.=7.	1.64(—).02
		Irregular.	H. **Tourmaline,** $R_{12}B_2(SiO_3)_4$		
>α-Monobrom-Naphthalin.	Gray or White.	Plates.	O. Zoisite, $Ca_2(AlOH)Al_2(SiO_4)_3$	Columnar and fibrous. Gray to pink masses and crystals. B.B. swells.	1.69(+).005
	Gray or White to Bright A.	Laths. Ex., 20°-25° El., (+).	M. **Spodumene,** $LiAl(SiO_3)_2$	Splits in broad plates. White to pale green H=7. Fl., red.	1.66(+).03
	Bright A to B.	Laths and Rhombs. Ex., about 40°.	M. **Pyroxene** (Diopside), $CaMgSi_2O_6$	Pale green or white crystals square or octagonal. Cleavage 87°.	1.67(+).03

18.

= Xylol.	Black or Gray or White. Gray or White to Bright A.	Irregular. Needles. Ex., ‖. El. (+)	I. **Analcite**, $NaAl(SiO_3)_2.H_2O$ O. **Natrolite**, $Na_2Al_2Si_3O_{10}+2H_2O$	Trapezohedra. Fl., yellow. Slender prisms. Square cross section low pyramid. Fl., yellow.	1.49 Isotropic or weak. 1.48(+).01
>Xylol <Bromoform.	Gray or White.	Irregular or Laths. Ex., ‖.	H. **Nephelite**, $Na_6Al_6Si_9O_{24}$	Little white hexagonal prisms or massive with greasy luster. Fl., yellow.	1.54(—).005
>Bromoform.	Bright B.	Irregular.	M. **Datolite**, $Ca(BOH)SiO_4$	Glassy crystals or porcelain-like masses. Fl., bright green.	1.67(—).045

19.

<Bromoform.	Gray or White.	Fine needles. Ex., ‖. El. (—).	—. **Ulexite**, $NaCaB_5O_9+8H_2O$	Balls of white silky fibres H=1. Fl., yellow.	1.50(+).01
	Gray or White, or Bright A.	Plates and Laths. Ex., on 001 4°, on 010, 20°.	Tri. **Plagioclase** (labradorite) $NaAlSi_3O_8.nCaAl_2Si_2O_8$	Gray, cleaving 86°. Often play of color. Striations.	1.55(+).01
=or>Bromoform.	Bright A.	Polygonal plates. Ex., ‖ or 20° to 25°.	M. **Colemanite**, $Ca_2B_6O_{11}+5H_2O$	Glassy crystals or porcelain or chalky masses. Fl., bright green.	1.59(+).02

20.

Certain varieties of **Plagioclase, Amphibole, Pyroxene and Spodumene** may work out here. See 17.

21.

CRUSHED FRAGMENTS.			Crystal System, Name, Composition.	NOTABLE MINERAL CHARACTERS.	
Index of Refraction.	Interference Color.	Other Notable Characters.		Appearance or Tests.	Index Refr. Sign and Birefringence.
>Methylene Iodide.	Masked.	Blue Irregular.	M. **Azurite**, $Cu_2(OH)_2(CO_3)_2$	Deep blue crystals and crusts.	1.83(+).02
	Masked.	Green Laths. Arrowhead twins. Ex., 23°.	M. **Malachite**, $Cu_2(OH)_2CO_3$	Bright green radiating fibres or crusts.	1.88(—).02

22.

<αMonobrom-Naphthalin.	Gray or White.	Plates.	T. Melilite, Ca.Al silicate	Short square or octagonal prisms.	1.63(—).001

23.

<Bromoform.	Gray or White.	Pale yellow Plates.	O. Autunite, $Ca(UO_2)_2(PO_4)_2 8H_2O$	Pearly yelow plates. Yellow solution in HNO_3	1.58(—).024
>Bromoform.	Black.	Green rectangles. Uniaxial Int. Fig.	T. Torbernite. $Cu(UO_2)_2(PO_4)_2+8H_2O$	Pearly green plates. Yellowish green solution in HNO_3	1.61(—).03
<αMonobrom-Naphthalin.	Bright A.	Laths. Ex., ‖. El., (—).	O. **Prehnite**, $H_2Ca_2Al_2(SiO_4)_3$	Smooth or drusy green crusts. H.6 to 6.5.	1.62(+).03
>Methylene Iodide.	Black.	Red. Irregular or Needles. Isotropic.	I. **Cuprite**, Cu_2O	Deep red to brownish red cubes, hairs, masses. Fl., emerald green.	2.85 0.0
	Bright A.	Green. Irregular or Laths. Ex., ‖, El., (+).	O. Brochantite, $CuSo_4 3Cu(OH)_2$	Emerald green needle crystals. Fibrous veins. Fl., emerald green.	1.74 ?
	Masked.	Green, Plates or Laths. Ex., ‖.	O. Atacamite, $Cu_2(OH)_3Cl$	Deep emerald green. Crystals and aggregates. Fl., blue and green.	1.88(—).02

24.

	Gray or White. to Bright A.	Pleochroic black to smoky. Irregular.	H. **Tourmaline**, $R_{12}B_2SiO_8$ (Dark Varieties)	Hemimorphic crystals. Triangular cross section. Fl., bright green.	1.64(—).02
<α Monobrom-Naphthalin.	Bright A to B.	Laths. Ex., 10°—20°. El., (+).	M. **Amphibole**, $RSiO_3$	Fibrous or prismatic with rhombic or sixsided section. Cl. and prism angle 125°.	
		Pleochroic green to yellow.	Actinolite, R=CaMgFe	Green, often radiated or fibrous.	1.64(—).03
		Feebly pleochroic green to yellow.	Pargasite, R=CaMgFeAl	Light green to brown crystals.	1.61(+).02
		Pleochroic green to brown.	Hornblende, R=CaMgFeAl	Green to brown crystals and fibres.	1.65(—).02
	Gray or White	Irregular.	Tri. Axinite, $H_2R_4(BO)Al_2(SiO_4)_4$	Clove-brown, or bluish crystals type triclinic. Fl., bright green.	1.69(—).01
	Gray or White.	Irregular.	T. **Vesuvianite**, $Ca_6(AlOHF)Al_2(SiO_4)_5$	Brown to bright green crystals and columns. Sometimes compact.	1.72(—).001
>α Monobrom-Naphthalin.	Bright A.	Laths. Ex., 10°, El. (+)	Tri. **Rhodonite**, $MnSiO_3$	Red to brownish crystals and granular masses.	1.74(—).02
<Methylene Iodide.	Bright A to B.	Laths and Rhombs. Ex., 30 to 54°. Rarely pleochroic.	M. **Pyroxene**, $RSiO_3$	Grains and crystals with square or octagonal cross section. Cleavage and prism angle 87°.	1.73(+).02
			Hedenbergite, $CaFe(SiO_3)_2$	Green to nearly black.	
			Augite, R=CaMgFeAl	Greenish black to black crystals.	1.71(+).02
	Bright B.	Pleochroic. Brown. Ex., 0° to 10°. El. (+).	M. **Amphibole**, Basaltic Hornblende	Black prisms sixsided cross section. Cl.Ang. 125°.	1.75(—).07
	Black.	Irregular. Tinted reddish, brownish, etc.	I. Garnet, $R_3R_2(SiO_4)_3$ most varieties.	Brown to black crystals and granular masses.	1.80 to 1.85 0.0
>Methylene Iodide.	Bright B.	Pleochroic green, yellow. Irregular.	M. **Epidote**, $Ca_2Al_2(AlOH)(SiO_4)_3$	Yellow green grains, fibers and crystals.	1.77(—).04
	High Order.	Pleochroic brown or colorless. Plates.	M. **Titanite**, $CaSiTiO_5$	Brown to green. Wedge-shaped crystals. Boiled with Sn and HCl violet.	1.93(+).12

25.

CRUSHED FRAGMENTS.			Crystal System, Name, Composition.	NOTABLE MINERAL CHARACTERS.	
Index of Refraction.	Interference Color.	Other Notable Characters.		Appearance or Tests.	Index Refr. Sign and Birefringence.
<α-Monobrom-Naphthalin.	High order.	Laths. Ex., ‖. El., (—).	O. **Strontianite**, $SrCO_3$	Nearly white columnar or compact. Fl., crimson.	1.62(—).18

26.

<Bromoform.	Gray or White	Fibres. Ex., ‖. El. (+). El. (+)	—. **Sepiolite**, $H_4Mg_2Si_3O_{10}$	Compact, earthy or fibrous. Co. Sol. pink.	1.55 †
	Gray or White to Bright A.	Laths. Ex., 35°—40°.	Tri. **Anorthite**, $CaAl_2si_2O_8$	Crystals or compact. Fl., red. 1+.=6.	1.59—.02
>Bromoform.	Gray or White	Laths or Needles. Ex., ‖. El., (+).	M. **Wollastonite**, $CaSiO_3$	White fibrous or compact or gray crystals. Fl., red H.=4.5—5.	1.63(—).014
<αMonobrom-Naphthalin.	Bright B.	Laths. Ex., ‖., El. (+).	O. **Calamine**, $(ZnOH)_2SiO_3$	Vitreous whitish crystal surfaces. Massive. B.B. white coat. Test H_2O.	1.61(+).03
>αMonobrom-Naphthalin.	Bright A to B.	Irregular.	If. **Willemite**, Zn_2SiO_4	Resinous yellow to green masses or grains. Coarse crystals. B.B. white coat.	1.70(+).02

27.

<Bromoform.	Gray or White. Aggregate.	Fibres. Ex., ‖. El. (+).	—. **Serpentine**, $H_4Mg_3Si_2O_9$	Fine grained, dull, often mottled greens, yellows, etc. H=4.	
			Chrysotile	Fibrous.	1.54(+).01
		Irregular.	Antigorite	Compact or lamellar.	1.57(—).01
	Gray or White		M. **Biotite.** See 28.		
	Gray or White to Bright A.	Pleochroic if colored.	O. Iolite, $H_2(Mg,Fe)_4Al_3Si_{10}O_{37}$	Blue vitreous masses or short prisms. H=7 to 7.5.	1.55(—).01
	Bright A.		M. **Colemanite.** See 19.		
>Bromoform. <Methylene Iodide.	Gray or White.	Irregular. Ex., ‖ cleavages.	H. **Apatite**, $Ca_5(F,Cl)(PO_4)_3$	Prisms, Resinous. Red, green, white, etc. Fl., red.	1.63(—).004
>Methylene Iodide.	Bright A.	Irregular.	T. **Scheelite**, $CaWO_4$	Adamantine pyramids and masses G.=5.4—6.1. In Ph. S with R. F. bead blue when cold.	1.93(+).02

28.

	Gray or White.	Pleochroic green. Aggregate.	**Chlorite.** M. Prochlorite, $H_8(Mg,Fe)_2Al_2Si_2O_{10}$	Dark green, scaly or interlaced lamellæ. H=1 to 2. After fusion is magnetic.	
	Gray or White.	Scales.	M. Clinochlore, $H_8Mg_5Al_2Si_3O_{18}$	micaceous flexible. H=2 to 2.5.	1.58(—).001 to .008
	Gray or White.	Irregular.	H. **Beryl,** $Be_3Al_2(SiO_3)_6$	Prisms, usually green or yellow. H=7.5 to 8.	1.58—.01
<Bromoform.	Gray or White to Bright A.	Laths. Ex., ‖ on 001, 5° on 010.	M. **Orthoclase,** $KAlSi_3O_8$	Crystals and masses with H=6. Rectangular cleavage.	1.58(—).005
	Gray or White to Bright A.	Laths. Ex., 15° on 001, 5° on 010. Crossed twinning (grating).	Tri. Microcline, $KAlSi_3O_8$	Green, white, etc. H=6. Striations frequent.	1.53(—).01
	Bright A.	Irregular.	O. **Talc,** $H_2Mg_3(SiO_3)_4$	White, gray or greenish foliated; compact or fibrous. H=1. Co. Sol. pink.	1.53(—).01
	Gray or White to Bright A.	Laths. Ex., ‖, El., (+).	—. Pyrophyllite, $HAl(SiO_3)_2$	Lammellar radiated or compact. H=1 to 2. Co. Sol. blue.	1.57—.04 1.59(—).02
>Bromoform.	Gray or White or Black.	Plates. Int. Fig. Uniaxial nearly angle 0° to 15°.	M. **Biotite,** $(KH)_2(Mg,Fe)_2Al_2(SiO_4)_3$	Dark mica in crystals scales or aggregates. Rarely large sheets.	1.64(—).03 to 1.57(—).06
	Gray or White or Black.	Plates. Int. Fig. large angle.	M. **Muscovite,** $H_2(K,Na)Al_3(SiO_4)_3$	Light colored mica. Crystals and lamellar masses often large sheets.	1.60(—).04
<αMonobrom-Naphthalin.	Gray or White or Black.	Plates. Int. Fig. angle 0° to 30°.	M. **Phlogopite,** $R_3Mg_3Al(SiO_4)_3$	Amber, mica in limestones and serpentines. Often large sheets.	1.61(—).05
	Gray or White to Bright A.	Irregular. Pleochroic and colorless.	H. **Tourmaline,** $R_{12}B_2(SiO^3)_4$ Colored varieties.	Transparent crystals often triangular cross section. Fl., green.	1.64(+).02
>αMonobrom-Naphthalin.	Gray or White to Bright A.	Laths and fibres. Ex., ‖. El. (+).	O. Enstatite, $(Mg,Fe)SiO_3$	Brown to green. Foliated. Pearly lustre.	1.66(+).01
	Gray or White to Bright A.	Laths and fibres. Ex., ‖. El. (+).	O. Hypersthene, $(Mg,Fe)SiO_3$	Foliated, metalloidal. Dark green to black. Fuses to a magnetic mass.	1.70(—).01

29.

CRUSHED FRAGMENTS.			Crystal System, Name, Composition.	NOTABLE MINERAL CHARACTERS.	
Index of Refraction.	Interference Color.	Other Notable Characters.		Appearance or Tests.	Index Refr. Sign and Birefringence.
<Xylol.	Gray or White.	Fibres. Ex., Obl.	M. Aluminite, $Al_2SO_{11}.9H_2O$	White chalky masses. H=1 to 2.	1.47(—).01
>Xylol.	Black.	Irregular. Clayey.	—. **Bauxite**, $Al_2O(OH)_4$	Oölitic or rounded or like clay. White to red.	1.57 varying
<Bromoform.	Gray or White.	Irregular. Twinning and inclusions.	I. **Leucite**, $KAl(SiO_3)_2$	White or gray trapezohedra.	1.51 .00 or (+).002
	Bright B.	Rectangles. Ex., ‖. El., (+).	O. **Wavellite**, $Al_6(OH)_6(PO_4)_4+9H_2O$	Circles of radiating crystals. White green or yellow.	1.52(+).03

30.

<Bromoform.	Gray or White.	Scales. Cloudy.	M. **Kaolinite**, $H_4Al_2Si_2O_9$	Clay-like masses. H=2 to 2.5.	1.55(—).007
	Gray or White.	Scales or aggregates.	M. **Gibbsite**, $Al(OH)_3$	Stalactites, crusts and rare crystals. H=2.5 to 3.5	1.55(+).02
	Gray or White or Black.	Six sided or irregular.	H. **Alunite**, $K(AlO_3)(SO_4)_2+3H_2O$	Fibrous, lamellar or small white cuboids. H=3.5 to 4.	1.57(+).02
>Bromoform.	Gray or White.	Plates with Biax. Int. Fig. and irregular.	O. **Topaz**, $Al(AlOF_2)SiO_4$	Glassy, colorless or yellow crystals with basal cleavage and rhombic section. H=8.	1.61(+).01
<αMonobrom-Naphthalin.	Gray or White to Bright A.	Irregular.	O. **Andalusite**, $Al(AlO)SiO_4$	Nearly square prisms, gray or pale red. H=7 to 7.5.	1.64(—).01

	Black.	Irregular. Tinted.	I. **Spinel**, $MgAl_2O_4$	Octahedrons. Black or bright colors. H=8.	1.72 0.0
	Gray or White to Bright A.	Irregular.	H. Phenacite, Be_2SiO_4	Lens shaped and rhombohedral colorless crystals. H=7.5—8.	1.65(+).02
> α Monobrom-Naphthalin.	Gray or White to Bright A.	Laths. Ex., 30°. El., (+).	Tri. **Cyanite**, $(AlO)_2SiO_3$	Blue bladed crystals, brighter color along central line. H=5 to 7.	1.73(—).016
< Methylene Iodide.	Bright A.	Laths or Needles. Ex., ‖. El., (+).	O. Sillimanite, Al_2SiO_5	Prisms and fibrous tough aggregating H.=6 to 7.	1.66(+).02
	Bright B.	Laths. Ex., ‖. El., (—).	O. Diaspore, $AlO(OH)$	Pearly, pink to brown, flattened crystals or lamellar masses. H=6.5 to 7.	1.70(+).05
> Methylene Iodide.	Gray or White to Bright A.	Irregular.	O. **Chrysoberyl**, $BeAl_2O_4$	Tabular, yellow or emerald green crystals, pseudo hexagonal H=8.5.	1.75(+).01
	Gray or White to Bright A.	Irregular.	H. **Corundum**, Al_2O_3	Adamantine. Crystals round or hexagonal section. Basal parting. H=8 to 9.	1.77(—).01

31.

< α Monobrom-Naphthalin.	High Order.	Plates or laths. Ex., ‖. El., (—).	O. **Aragonite**, $CaCO_3$ **Calcite**, **Dolomite**, **Magnesite**, } ‖ short Diagonal	Prisms or needles often pseudo hexagonal. Coral-like. Violet when boiled with Co. Sol. See below.	1.69(—).15
	High Order.	Aggregate.	**Magnesite.**	White chalk-like masses.	
Equal α Monobrom-Naphthalin.	High Order.	Rhombs. Striatious ‖ long diagonal. Ex., Sym.	H. **Calcite**, $CaCO_3$ ‖ long diagonal	Crystals, granular masses. Cleavage angle 105°.	1.66(—).17
> α Monobrom-Naphthalin.	High Order.	Rhombs. Ex., Sym.	H. **Dolomite**, $CaMg(CO_3)_2$	Marble or curved rhombohedra. Slow effervescence of lumps.	1.68(—).19
	High Order.	Rhombs. Ex., Sym.	H. **Magnesite**, $MgCO_3$	White chalk-like masses. Rhombohedral crystals. Co. Sol. Pink.	1.72(—).20
< Methylene Iodide.	High Order.	Rhombs. Ex., Sym.	H. **Rhodochrosite**, $MnCO_3$	Pink to red rhombohedral crystals or masses. Test for Mn.	1.82(—).22
> Methylene Iodide.	High Order.		**Rhodochrosite**, ‖ long diagonal	See above.	

32.

CRUSHED FRAGMENTS.			Crystal System, Name, Composition.	NOTABLE MINERAL CHARACTERS.	
Index of Refraction.	Interference Color.	Other Notable Characters.		Appearance or Tests.	Index Refr. Sign and Birefringence.
$<\alpha$ Monobrom-Naphthalin.	Bright. A.	Irregular. Colorless or pleochroic yellow.	M. Chondrodite, $H_2Mg_{10}Si_5O_{24}F_4$	Brown to yellow grains, crystals and masses. H=6.5.	1.61(+).03
$>\alpha$ Monobrom-Naphthalin.	Bright B.	Irregular, colorless, yellow.	O. **Chrysolite**, $(Mg,Fe)_2SiO_4$	Olive to gray-green grains. Glassy. Loses color on heating. H=7.	1.66(+).04
	Masked.	Plates or Irregular. Green.	H. Dioptase, H_2CuSiO_4	Emerald green crystals with rhombohedron. H=5. Fl., Emerald green.	1.67(+).05
> Methylene Iodide.	Black.	Often isotropic.	T. Thorite, $ThSiO_4$	Orange to brown, zircon shaped crystals usually altered.	<1.75+ !

33.

< Bromoform.	Black or Gray or White.	Plates, Fibres, Ex., ‖. El., (—).	H. **Brucite**, $Mg(OH)_2$	Foliated or fibrous. Pearly lustre. Co. Sol. Pink.	1.56(+).02
	Black or Gray or White.	Pale blue or green. Irregular.	—. **Chrysocolla**, $CuSiO_3+2H_2O$	Green to sky-blue with waxy lustre.	±1.57 weak
= Bromo form.	Gray or White.	Greenish. Irregular.	—. **Garnierite**, $H_2(Ni,Mg)SiO_4+H_2O$	Deep green to pale green. Soft and friable. Test Ni.	±1.59 weak
> Bromoform.	Gray or White.	Aggregate.	—. **Turquois**, $Al_2(OH)_3PO_4.H_2O$	Sky blue to green with lustre of wax. Massive.	1.61 weak
	Bright B.	Plates. Faint yellow.	M. Monazite, $(Ce,La.Di)PO_4$	Resinous brown crystals or yellow grains.	1.80(+).04

34.

<Xylol.	Black.	Irregular. Colorless or colored.	—. **Opal**, SiO_2nH_2O	Porcelain-like veins and linings with conchoidal fracture. Rarely play of colors. H=5.5 to 6.5.	1.40 to 1.46 Isotropic.
	Gray or White.	Plates. Twinned.	H. Tridymite, SiO_2	Minute tabular crystals. H=7.	1.48(+).002
>Xylol.	Gray or White to Bright A.	Irregular.	H. **Quartz**, SiO_2	Vitreous crystals and massive. Of many colors. H=7.	1.54(+).01
<Bromoform.	Gray or White to Bright A.	Irregular. Fibrous with crossed Nicols. El., (—).	—. Chalcedony	Translucent crusts or concretions wax-like lustre. Not in crystals.	1.55(—).01
>Bromoform. <αMonobrom-Naphthalin.	Gray or White to Bright A.	Irregular. Red, pleochroic.	H. **Tourmaline**, $R_{18}B_2(SiO_6)_4$ (Rubellite)	Transparent deep red.	1.64(—).02
Equal Methylene Iodide.	Gray or White.	Irregular.	O. **Staurolite**, $Fe(AlO)_4(AlOH)(SiO_4)$	Dark brown rhombic prisms. Usually twinned. H=7.5.	1.74(+).01
>Methylene Iodide.	Black.	Irregular.	I. **Garnet**, Uvarovite, $Ca_3Cr_2(SiO_4)_3$	Emerald green dodecahedra. H=7.5.	1.83 .00
	Black.	Irregular.	I. **Diamond**, C	Colorless, or colored crystals. H=10. Adamantine. G=3.51.	2.42 .00
	Bright B.	Irregular.	T. **Zircon**, $ZrSiO_4$	Sharp cut pyramid and prism. Adamantine lustre. H=7.5.	1.95(+).05
	Bright B.	Irregular.	T. Octahedrite, TiO_2	Brown or steel blue pyramids. Adamantine lustre.	2.53(—).06
	High Order.		T. Cassiterite. SnO_2	See 7.	2.00(+).10
	High Order.	Irregular. Yellow to reddish.	T. **Rutile**, TiO_2	Red to black. Adamantine. Prisms, often needles. G=4.2.	2.76(+).28

INDEX TO MINERAL TABLES.

Mineral.	*Table.*
Actinolite	24
Albite	17
Aluminite	29
Alunite	30
Alunogen	2
Amblygonite	17
Amphibole	17, 24
Analcite	18
Andalusite	30
Anglesite	7
Anhydrite	16
Annabergite	3
Anorthite	26
Apatite	27
Aphthitalite	1
Apophyllite	15
Aragonite	31
Atacamite	23
Autunite	23
Axinite	24
Azurite	21
Barite	17
Bauxite	29
Beryl	28
Biotite	27, 28
Bismite	6
Bismuthinite	5
Boracite	16
Borax	1
Brochantite	23
Bromyrite	7
Brucite	33
Calamine	9, 26
Calcite	31
Calomel	11
Cancrinite	14
Carnallite	1
Cassiterite	7, 34
Celestite	17
Cerargyrite	7
Cerussite	5
Chabazite	15
Chalcanthite	1
Chalcedony	34
Chlorite	28
Chondrodite	32
Chrysocolla	33
Chrysolite	32
Chrysoberyl	30
Cinnabar	11
Colemanite	19, 27
Copiapite	2
Corundum	30
Crocoite	6
Cryolite	16
Cuprite	23
Cyanite	30
Datolite	18
Descloizite	6
Diamond	34
Diaspore	30
Dioptase	32
Diopside	17
Dolomite	31
Embolite	7
Enstatite	28
Epidote	24
Epsomite	2
Erythrite	3
Fluorite	16
Garnet	24, 34
Garnierite	13, 33
Gibbsite	30
Goethite	13
Goslarite	2
Greenockite	8
Gypsum	16
Halite	1
Hedenbergite	24
Hematite	13
Heulandite	16
Hydrozincite	8
Hypersthene	28
Iodyrite	7
Iolite	27
Kainite	1
Kalinite	1
Kaolinite	30
Kermesite	6
Labradorite	19
Lazurite	15
Lepidolite	17
Leucite	29
Limonite	13
Linarite	7
Magnesite	31
Malachite	21
Melanterite	2
Melilite	22
Microcline	28
Mimetite	3
Minium	6
Mirabilite	1
Molybdite	10
Monazite	33
Muscovite	28
Nephelite	18
Nitre	1
Octahedrite	34
Oligoclase	17
Olivenite	3
Opal	34
Orpiment	4
Orthoclase	28
Pectolite	15
Petalite	17
Phenacite	30
Phlogopite	28
Phosgenite	5
Plagioclase	17, 19
Prehnite	16, 23
Proustite	4
Pyrargyrite	7
Pyromorphite	6
Pyrophyllite	28
Pyroxene	17, 24
Quartz	34
Realgar	4
Rhodonite	24
Rhodochrosite	31
Rutile	34
Sal Ammoniac	2
Sassolite	1
Scheelite	27
Senarmonite	6
Serpentine	27
Sepiolite	26
Siderite	12
Sillimanite	30
Smithsonite	8
Soda Nitre	1
Sphalerite	8
Spinel	30
Spodumene	17
Staurolite	34
Stilbite	16
Strontianite	25
Sulphur	11
Sylvite	1
Talc	28
Thenardite	1
Thomsonite	15
Thorite	32
Titanite	24
Topaz	30
Torbernite	23
Tourmaline:	
" Brown	17
" Dark	24
" Colored	28
" Rubellite	34
Tridymite	34
Trona	1
Turgite	13
Turquois	33
Ulexite	19
Valentinite	6
Vanadinite	6
Vesuvianite	24
Vivianite	13
Wavellite	29
Wernerite	16
Willemite	9, 26
Witherite	14
Wollastonite	15, 26
Wulfenite	6
Zincite	10
Zircon	34
Zoisite	17

CONSERVATION.*

BY JAMES DOUGLAS.

Judging from the public press and from some of the recent political utterances, the members of the mining profession have been systematic wasters instead of savers. In a certain sense the charge is justifiable; in a wider sense it is certainly unfair. I can look back a long way. I recollect the north of England, before the introduction of the Whitwell stove, when it was always under a canopy of smoke from the blast furnaces, and was appropriately called "the black country." It is little more than a generation ago that the Bessemer converter was introduced; and, now, where water power is available, steel can be produced without the consumption of any fuel. In other branches of our profession we have seen metallurgy completely revolutionized. To-day about $20,000,000 worth of gold and silver is annually recovered in the electrolytic refining of copper, which, under the old Welsh method, went to waste. Moreover, through the ingenuity of civil and mechanical engineers such improvements in boiler and steam engine construction have been made that 1¼ lb. of coal are made to do the work of 10 lb. a century ago.

The economies of the past have been brought about by the combined efforts of the engineer and the chemist, with the aid of the miner. All must work together if the best results are to be obtained. In fact, one reason why conservation in this country today is not more perfectly accomplished is because coöperation among the great national industries is not more actively practised. The valuable products of coal in coking would not be wasted if the chemical industry had kept pace with the metallurgical.

The older one grows, the more one is inclined to fall back upon his reminiscences, and you must excuse me if I yield to this weakness. I recollect the mining and metallurgy of Arizona when they were in their infancy. Their birth coincided with the introduction of the first line of railroad, for a railroad is a necessary part of the equipment of a modern mine or furnace plant. With

*An address delivered at Columbia University, Jan. 6, 1913.

the advent of the Southern Pacific, there were opened actively three of the mining districts which are still supreme in Arizona. They are the Warren district, where the Copper Queen and the Calumet & Arizona companies are operating actively; the Clifton district, which had been opened some years previously on a small scale by the Lezinskys; and the Globe district, which was separated from the railroad by about 140 miles.

At that time it was considered fortunate that all the copper ores of southern Arizona were oxidized, and that the copper could therefore be extracted by a single fusion in the cupola. We all thanked heaven that we had a large supply of those ores, and were not obliged to make matte. The result was that we all made metallic copper direct, but only the Copper Queen company made money. Now, making money as a primary object may be a very ignominious operation, but at the same time you will find that unless you can make money for your employers, before long your job will fail. In the case of Arizona this was not strictly true. The temptations to proceed were so great that, in spite of the steady absorption of capital for many years, operations continued. The cause of failure was the loss of copper in the slags when making copper direct. The ores as they came from the Copper Queen mine were self-fluxing. In fact, the furnace mixture was sometimes too basic. Those of Globe and Clifton were so acid that an equal amount of flux, generally barren of copper, had to be added to the furnace charge, reducing the percentage of metal in the charge correspondingly, and more than correspondingly increasing the loss of copper in the slag, for an artificial furnace mixture seldom gives as good smelting results as a naturally fusible ore. The result was that the slags of the Copper Queen mine did not run much over 2 percent., while those of the Clifton and the Globe districts rose to 3.5 and even 4 percent. of copper, extracting twice that amount from the ore.

Under such conditions the slags almost unavoidably carry the whole of the profits, even if the ore be rich. There was only one short period during which the Globe mines made any money, and that was under the good business administration of Mr. Keyser and the admirable metallurgical management of your Professor

Walker. Outside of that short period, for many years the mines of the Globe and Clifton districts lost money. But had the slags been everywhere conserved, the copper contents could to-day be recovered. This, in some cases, was done of necessity. Those who had the seeming advantage of granulating their slags and washing them away in a current of water threw away the copper that should have been simply reserved for future treatment. The furnaces of the Arizona Copper Company at Clifton, which was one of the largest producers in the Territory, were on the banks of the San Francisco River, and we envied that company the advantage of the operating economy which that river afforded them for disposing of their slags. To-day the Detroit Copper Company, operating in that region, but far from water, is thankful that it has slags to retreat which are richer in copper than its present ores. The moral is — never put out of reach, or store where it will decay and go to waste, material which, though valueless now, may hereafter be utilized to a profit.

It is seldom, almost never, possible to introduce theoretical conservation or economies, but you should always bear in mind that what to-day may be useless from an economical point of view, may some day be valuable, and what you may now look upon as waste, ought to be stored for a coming generation. This is about as far as you can go to-day in conserving the national resources. You cannot avoid wasting something in working up the complicated elements which compose most ores. In the development of a new and isolated district, unless you commit, for the time being, the unavoidable crime of wasting, you cannot build up a big industry to the point at which the conditions will be ripe for actual economical treatment. For example, in Arizona, in the days of which I am speaking, the production of those three districts was about 1,500,000 lb. of copper a month. To-day Arizona is turning out 350,000,000 lb. of copper a year. That increase would not have been brought about if the miner and metallurgist had sat down and waited for better economical conditions; or if capital had been timid and, in spite of losses, had not been willing to pour money into the development of the properties, so that it would be possible to-day to introduce economies.

Yet the prosperity of to-day is due to the existence of a condition which in the early days would have been considered absolutely prohibitory — the presence of sulphur in the ore. It would have obliged us to make matte, and until the Bessemer converter was adapted to the metallurgy of copper, the reduction of matte was slow and costly in labor. Sulphides are still scarce in Globe, but the railroad enables us to interchange ores, and thus Bisbee can give to Globe her surplus of sulphides in exchange for silicious ore and even flue dust. This is only one of the minor benefits which the railroads have conferred on Arizona, converting her from an almost unpopulated desert into a State, with a prosperous community, in 33 years. But if we had aimed at perfection, which would have been impossible, instead of making the best of the conditions which faced us, Arizona would still have been an almost uninhabited waste. I do not pretend that we, as miners or as railroad builders, followed the line of action which was pursued, as a matter of principle. We had prospective profits in view, but as business men and miners, in and out of Arizona, we had faith in its future and belief in its resources; and one result has been that her copper mines, from a comparatively small area, turn out 12.8 percent. of the world's total product.

Nevertheless this economic question of conservation constantly faces us. Very few metallurgical processes are perfect from a metallurgical point of view. I know of none in which virtually all the elements of the ore are recovered, unless it be the treatment of the higher-grade Rio Tinto ores. The whole story of the Rio Tinto and of the ores of that great chain of sulphur lenses, which extends through southern Spain and into Portugal, is most interesting. Between 1860 and 1870, when it was recognized that sulphuric acid, for most purposes, could be made more profitably from pyrites than from Sicilian sulphur, the three principal pyrites companies of Spain and Portugal were organized to work old mines. The order of their importance was Rio Tinto, Tharsis, and Mason and Barry. The deposits had been worked intermittently from prehistoric times, but never with the energy which the demand for sulphur has created. The Mason and Barry Company, of Portugal, was forbidden by law to roast the ores, to

the detriment of vegetation, so they piled the leaner ores into heaps and shipped the richer ores abroad. They found that the heaps, watered by rain, yielded their copper, and therefore from the first they involuntarily practised natural cementation. The Rio Tinto and the Tharsis companies, on the other hand, roasted their leaner-grade ores in heaps to sulphatize the copper, preparatory to leaching. They thus wasted an enormous amount of sulphur, destroying vegetation and getting very imperfect results. At length they fell back upon natural cementation; and to-day you can witness at Rio Tinto the most interesting metallurgical operation on earth, for the company is doing artificially, rapidly, and on a small scale, what nature has been accomplishing underground over a long period of time.

The Rio Tinto company usually sorts its ores into two grades, the richer ores being shipped abroad to all the great chemical centers where they are generally treated by the Longmaid process as modified by Henderson. This is one of the few processes in which everything is recovered. After the sulphur has been converted into sulphurous and this into sulphuric acid, the cinder is roasted with salt to chloridize the copper, the silver, and a portion of the gold. The hydrochloric acid from the fumes is condensed in a tower. The copper and silver are extracted by leaching; the silver is precipitated from the mixed solution by iodide of zinc and the copper in metallic form by iron. The ferric oxide (blue billy), freed from sulphur and copper, is turned over to the iron and steel manufacturers.

The second-grade ore is built into heaps of about 10,000 tons, which are irrigated from the surface, at intervals, with water and with the liquors, containing ferrous and ferric sulphates, from the precipitating vats. By percolating through these great heaps those solvents extract, during the first year, nearly one-half of the copper, and during the second, third and fourth years, substantially all the remainder. At the end of four years the heap is broken up. The lumps of pyrites are dry to the touch, and to all appearances are unaltered in size and structure. But, though the ore was broken to fist size and was hard and compact, the liquors have permeated even the larger pieces, have decomposed a certain amount of the iron pyrites,

making salts of iron, which have helped to extract the copper, and have raised the sulphur contents from 48 percent. to over 50 percent.. increasing therefore its value to the acid makers of both continents. Seeing reactions like these going on under artificial conditions, one begins to conceive how the very small amount of insensible moisture, permeating rocks carrying a minute quantity of mineral ingredients, can extract the metals from them, and redeposit and concentrate them into veins or enriched secondary ores. The carrying out of the perfect Rio Tinto methods is possible because the chemical markets of the world are open to the company's products and by-products; whereas one reason why the recovery of by-products is less advanced in America than in Europe is that the chemical industry here has not made progress at the same rate as the metallurgical industry.

The population of our country has, in half a century, grown from 37,500,000 to nearly a hundred millions. Our railroad mileage in the same period has increased from about 30,000 miles to 244,000 miles. Our architects have rejected stone and mortar in favor of metal to such an extent that an ordinary skyscraper consumes 10,000 tons of steel. The demand for metal in enormous quantities has therefore been so urgent that attention to minute economies has been overlooked to perhaps a reprehensible extent, and chemical products being less in popular demand than metal, chemical manufacturing has not advanced so rapidly as the metallurgical. Yet until these twin industries keep pace with one another we have to go on wasting. Sulphur is one of the most valuable constituents in our ores that is going to waste. It does seem opprobrious that within sight of such a hive of industry as our city, clouds of sulphurous acid should be issuing from chimneys on the New Jersey Coast, and floating out to sea over Staten Island. The Tennessee Copper Company has set us an example. By utilizing the sulphurous acid of their furnace gases, they have brought down the price of sulphuric acid to $5.00 a ton, and they are in that way stimulating the superphosphate and general chemical industry over a wide region, by placing sulphuric acid in the industrial centers of the Southwest and Middle West at about $8.00 a ton.

If the Copper Queen company could find or make a market in the

Rocky Mountains for sulphuric acid, we would gladly occupy it. In Douglas, at the present time, from the ores of the mines of that neighborhood, we are wasting enough sulphur to make 500 to 600 tons of oil of vitriol per day. The production of acid in Butte would reach thousands of tons a day, if they could only convert their sulphurous fumes into sulphuric acid and find a market for it. In the South we are looking to the islands of the Pacific for phosphates. Butte is not very far from the phosphate deposits of Wyoming and Idaho. The farmers of the prairie States and the Pacific Coast will absorb at no distant date all the fertilizers we can make, but they are loath to spend money on soil which nature has so bountifully and gratuitously enriched.

At present, the most obstinate case of waste is undoubtedly in the handling of coal. But there again coal mining has progressed at such a terrifically rapid rate that it would have been almost impossible to practise perfect economy, even if the chemical manufacturer had kept pace with the coal mine, which he has not done. Even under unbridled competition more coal is not extracted than is consumed; but the price is so low that it hardly warrants using the economies which ought to be carried out in the mining and the handling of the coal, and the making of coke. I do not think that cheapness is an unmixed benefit. But apart from the question of price, there arises that of the utilization of by-products. Forgive me if I draw again from experience. In the northern part of New Mexico we are mining nearly 1,500,000 tons of coal a year, and are making about 350,000 tons of coke per annum. We are trying to do the best we know how, but we do not pretend for a moment that our operations are as economical as they would be under ideal conditions. Instead of bee-hive ovens we have erected underflue ovens, which are a kind of make-shift between the ordinary bee-hive oven and the by-product oven, the flue being constructed with a view to preserving the heat of the gases on their passage from the ovens to the steam boilers. We thus generate by the waste gases all the steam we need for the washery, the pumps, transportation service, and coal-cutting machinery; but we have enough waste heat to generate 5,000 horsepower more if we could find any service for it. We are looking for a subterranean water supply to irrigate the mag-

nificent land around us, which is athirst for moisture, but as yet the water has eluded us.

It is easy to talk about conservation of natural resources, but it is not so easy actually to bring about the desired result in most of the regions where mining and metallurgy are most active.

In the coking of coal there is the most glaring waste. In Germany more than half the coal is coked in by-product ovens, in England about 25 percent. and here only about 20 percent. That is because Germany has taken the lead in those branches of the chemical industry of the world which involve the most minute study, outstripping even England. The basic analine patents, on which the prosperity of the coal-tar trade largely rests, were English patents, but Germany has become the greatest workshop of these delicate products which we use and import so abundantly. Moreover, we import cresote to preserve our railroad ties, paying in the West nearly three times what it costs in Europe, while the sky is lurid from the burning gases of bee-hive ovens. Sulphate of ammonia will be in increasing demand as the farmer wakes up to the necessity of fertilizing his depleted fields.

We have not been blameless in the past. Exuberant energy has been displayed in meeting the most urgent demands of our growing population by increasing our transportation and metallurgical facilities. But the era of more careful conservation has been reached, and you who are entering the domain of mining and metallurgy will have to practice more minute and careful methods than we, whom you are replacing, have followed in trying to meet the demands of the recent period of perhaps abnormal national expansion. Properly to fulfil these functions you must give more attention than we have done to chemistry. We cannot in any case be metallurgists unless we are, so to speak, chemists; but the careful and minute study of industrial chemistry will become more and more in the future a branch of metallurgical practice, and consequently a subject of investigation. With the steady flow of population westward, all industries, with their students and operators, will follow. Those of you who follow the call to the westward will have, in some respects, a more difficult task than we older ones had to face, for the cream has been skimmed from most of the

large mineral deposits. To realize profits from the enterprises you will have under your charge, you will therefore be obliged to study methods more scientifically and apply management even more economically than we have practised. We have blazed the trail you will follow toward industrial perfection. You will not reach it. But each generation has fresh tasks to fulfil; it must not only cultivate new fields of investigation but must stimulate dormant faculties, if the uplift of the race is to be maintained.

SMELTING IN SHAFT FURNACES AT GREAT ALTITUDES.

BY VINCENTE PAZOS Y SACIO.*

The numerous failures made in Peru in attempts to smelt raw copper ores seem to result from lack of knowledge of the behaviour of shaft furnaces at the great altitudes at which they are generally worked. The following hints, deduced from observation and proved by numerical results, perhaps may be found useful by those who have to manage furnaces in such places.

The solution of the following problem will give a practical insight on the vital point.

Problem: — What will be the temperature of a water-jacket furnace in Cerro de Pasco where the atmospheric pressure is 8.75 lb. per sq. in.,[1] when the same furnace at sea level (15 lb.) gives 1,365° C.?

By the laws of combustion we have:

$$C + O_2 = CO_2, \text{ developing } 8{,}100 \text{ calories} \ldots\ldots (1)$$
$$1 \text{ Kg.} + 11.56 \text{ Kg.} = 12.56 \text{ Kg.}$$

or 1 Kg. of carbon combining with the oxygen of 11.56 Kg. of air gives 12.56 Kg. of heated gases which produce 8,100 kilogram-calories.

Assuming that the coke contains 10 percent. ash; the carbon in each kilogram of fuel will be 0.9; and equation (1) will reduce to:

$$C + O_2 = CO_2 = 7{,}290 \text{ Kg.-cal} \ldots\ldots (2)$$
$$0.9 \text{ Kg.} + 10.4 \text{ Kg.} = 11.3 \text{ Kg.}$$

If the above reaction did not produce heat, the volume of the gases at 0° C. and 76 cm. (15 lb.) pressure, would fill:

$$10.4 \div 1.3 = 8 \text{ cu. meters} \ldots\ldots (3)$$

But the reaction generates a great quantity of heat, which we have supposed raises the temperature to 1,365° C.

This temperature has been assumed because it gives an even expansion of the gases, and it is near the minimum at which raw cop-

* Sociedad de Ingenieros, Lima, Peru. E.M., Columbia, 1878.

[1] This is the pressure at the American smelter near Cerro de Pasco.

per ore can practically be smelted. (Richards, "Metallurgical Calculations"; Peters, "Principles of Copper Smelting.")

Since air at 8.75 lb. pressure is lighter than at 15 lb., and as the temperature depends on the relative weights of carbon and air combined in a given time, to burn 1 Kg. of 10 percent. ash coke, which at the coast needs 8 cu. meters of air, at Cerro will need in the same time and at the same initial temperature:

$$8 \times (15 \div 8.75) = 13.71 \text{ cu. meters} \ldots\ldots\ldots\ldots (4)$$

We see then, that if a furnace is designed to burn, at sea level, a certain quantity of coke, to fit this to burn the same quantity at Cerro, the capacity of the blowers, air conduits, and the area of the tuyeres must be increased about 70 percent. If these changes are not made, but the blowers are only run faster, the blast-pressure will increase, introducing evils of which I will treat later, and at the same time the blowing engine will be forced to do a great deal of useless work, increasing leakage at a ratio which will surprise men who have had no experience in high altitudes.

The problem of the volume of air, which now looks so simple, was solved on a scientific basis by Mr. Chapponi about 30 years ago. Before him the greater part of those who tried smelting in the "Cordilleras," blew *too little,* although some went to the other extreme and blew *too much* air; but none could tell in a scientific way the amount that should be blown. As up to that time the results of shaft-furnace smelting had been unsatisfactory, it became an axiom that "smelting in shaft furnaces is impossible in the high cordilleras of Peru." Engineers of almost all nations had tried it and failed. Percy, in the older editions of his "Metallurgy," treats of this subject.

Let us now see if the same amount of carbon burnt in the same time at Cerro de Pasco affords the same temperature as at sea level. If we take one cubic meter of the eight (equation 3) formed by the combustion of 1 Kg. of 10 percent. ash coke, and enclose it in a prism one meter square,

At 0° C. the gases will fill 1 meter of the prism.
" 273° " " " " 2 " " " "
" 546° " " " " 3 " " " "
" 1,365° " " " " 6 " " " "

Thus the assumed temperature of the furnace expands the gases to six times their volume at 0° and 15 lb. pressure.

If we plot this, (see plate) taking the origin of coördinates at O, which represents absolute zero, and making Oy, Ox, represent respectively the absolute volumes and pressures, then the point t_{15} can be made to represent the temperature 1,365° C., since the line Ov_{15} represents the absolute volume of 6 cu. meters and the line Op_{15}, the absolute pressure of 15 lb. at sea level.

The subfixes of p, v, and t, in the plate, represent the pressures in pounds to the inch, to which the different pressures, volumes, and temperatures correspond. To find the relative values of temperature, pressure, and volume at any other point, we have simply to pass a curve of expansions through the point t_{15}.

Since a furnace made for sea-level work, by increasing the volume of the blast, can be made to burn the same quantity of coke at Cerro, the rate of burning is the same.

As the heat of combustion inside a furnace continually replaces the heat spent, and as the number of heat units, no matter at what temperature, will always be constant, the curve we are looking for must be an isothermal, no matter how much the atmospheric pressure may vary. In other words, we wish to find the quantity of coke necessary to keep a fixed temperature of 1,365° at a pressure which varies from 15 to 8.75 pounds.

An isothermic is an equilateral hyperbola

$$p\ v = P\ V = \text{constant.}$$

In our case P = 1 atmosphere = 15 lb. per inch = 10,333 Kg. per sq. meter.

V = 6 cu. meters, which is our starting volume at sea-level pressure and at 1,365° C. temperature. From the nature of the curve of expansion, it is quite easy to find as many points as wanted. Since $p\ v = P\ V$, $v = P\ V \div p$.

If we call $v_{8.75}$ the volume at Cerro; as we know P, V, and $p_{8.75}$, the pressure at Cerro, we have:

$$v_{8.75} = (15 \times 6) \div 8.75 = 10.28 \text{ cu. meters.}$$

Now we know p_{15}, v_{15}, and t_{15}, at sea level, and $v_{8.75}$, $p_{8.75}$ at Cerro; from these we can find $t_{8.75}$. The gases, in expanding from v_{15} to $v_{8.75}$ have done work; this work has consumed heat and

this disappearing heat must be felt at $t_{8.75}$. The problem, then, has reduced to measuring the work of expansion and converting it into heat.

The work done is represented in the diagram by the area bounded by the lines $(t_{15}\ldots.v_{15})$, $(v_{15}\ldots.v_{8.75})$ $(v_{8.75}\ldots.t_{8.75})$ and $(t_{8.75}\ldots.t_{15})$, which represents a given volume displaced by a certain varying pressure. From the nature of the curve, this area is the same as that enclosed by the lines $(p_{8.75}\ldots.p_{15})$ $(p_{15}\ldots.t_{15})$, $(t_{15}\ldots.t_{8.75})$ and $(t_{8.75}\ldots.p_{8.75})$, which represents a varying volume displaced between two pressures.

As the first area is the more natural representation of the expansion of the gases, between two given pressures, we will evaluate it first, using simply arithmetical work. Of course this valuation, although good enough for practical purposes, is only a rough approximation, for we consider the hyperbolic arc $(t_{15}\ldots.t_{8.75})$ as a straight line.

$$\text{Area} = \frac{(p_{15} + p_{8.75})}{2} \times (v_{8.75} - v_{15}) = \text{(using the metric equivalent)}$$

$$\frac{10{,}333 + 6.611}{2} \times (10.28 - 6) = 36{,}260.16 \text{ kg.-meters.}$$

Thus 1 cu. meter of the gases of combusion, in expanding from 15 lb. to 8.75 lb. pressure has done 36,260.16 kg.-meters of work. As there were 8 cu. meters of gas (Eq. 3) formed in the combustion of 1 kg. of 10 percent. ash coke, the total for 1 kg. of coke will be:

$$36{,}260.16 \times 8 = 290{,}081.12 \text{ kg.-meters.}$$

As 425 kg.-meters = 1 kg.-calorie, the loss of heat will be:

$$290{,}081.12 \div 425 = 682.54 \text{ kg.-calories.}$$

If closer work is wanted, then the true value has to be used. From the equation of the curve, we have

$$vp = K = PV, \text{ or } v = \frac{K}{p} = \frac{PV}{p}. \qquad \int vdp = K \int \frac{dp}{p}.$$

Integrating between p_{15}, which is P, and $p_{8.75}$, which is $(7 \div 12)$ P, we have:

$$K \int_{\frac{7P}{12}}^{P} \frac{dp}{p} = K \left(\log_e P - \log_e \frac{7}{12} P \right) = K \log_e \frac{12}{7} =$$

$$PV \log_e \frac{12}{7} = 10{,}333 \times 6 \times 0.5365 =$$

33,261.9 kg.-meters per meter gas.....(5)
33,261.9 × 8 = 266,095.2 kg.-meters per kg. coke.
266,095.2 ÷ 425 = 626.1 kg.-calories per kg. coke.

We see thus that, in the case we are considering, a furnace working under a pressure of 8.75 lb. loses 262.1 calories as compared with a similar furnace working under 15 lb. pressure.

Let us now find the relative efficiency: Of the 8 cu. meters made as products of combustion, 1.6 cu. meters practically represent the CO_2 formed, and 6.4 cu. meters practically represent the N in the air.

These give a calorific capacity as follows:

$CO_2 = 1.6(0.37\,t + 0.00022\,t^2) = 1{,}463.8$ cal.
$N = 6.4(0.303\,t + 0.000027\,t^2) = 2{,}962.9$ "

$t = 1{,}365°$ C. 4,426.7 "

Thus the efficiency of the fuel of the furnace at the tuyere zone, and under a pressure of 15 lb., is 4,426.7 ÷ 7,290 = 60 percent.= 1,365° C.

At Cerro, under a pressure of 8.75 lb., owing to the heat lost by the expansion of the gases, the same furnace, with the same weight of air, which means 70 percent. more volume blown in the same time, and with the same weight of fuel, will give only (4,426.7 − 626.1) ÷ 7,290 =52.1 percent.= 1,184° C. Thus the furnace at Cerro has lost 13.2 percent. calorific capacity, as compared with the same furnace at sea level.

This is on the assumption that the air is perfectly dry. To obtain closer results, we will make an approximation to bring the respective temperatures nearer to their true values.

At sea level, owing to the greater pressure and temperature the air, especially in tropical latitudes, contains a quantity of water vapor which cannot be disregarded; while on the high altitudes of the Andes, the low pressure and temperature make atmospheric moisture very small. At sea level, the air will be blown at a mean temperature of 25° C., while at Cerro the mean will be 6°, varying during the day from 1° to 11°. Not taking into account the initial temperature of the air at the two places, we will simply estimate the moisture which, at the coast, has to be heated to the required temperature of 1,365° C.

At 76 cm. pressure and 25° temperature, 1 kg. of air at saturation point contains 19.47 grams of water vapor. As 10.4 kg. of air were needed (Eq. 2) for the combustion of 1 kg. of coke, the total amount will be practically $10.4 \times 19.47 = 202$ grams water vapor at 25°, or in round numbers, 0.2 kg. The heat necessary to bring this water to a temperature of 1,365° is:

$$0.2[0.42(t_2 - t_1) + 0.000185(t_2 - t_1)^2] = 112.7 \text{ kg.-calories.}$$
$$(t_2 - t_1) = 1365° - 25° = 1340°$$

The mean temperature of 6° C. represents a moisture of 5.71 grams per kg. of air; but as this temperature exists at a pressure of 8.75 lb., there is no error in reducing pressure to temperature

$$\frac{\text{Absolute press. at Cerro}}{\text{Absolute press. at sea}} = \frac{\text{Absolute temp. at Cerro}}{\text{Absolute temp. at sea.}}$$

From the above relation, we obtain:

$$p_{15}\, v_{15}^{1.15} = p_{8.75}\, v_{8.75}^{1.15}. \quad \text{Hence } \frac{T_{8.75}}{T_{15}} = \left(\frac{p_{8.75}}{p_{15}}\right)^{\frac{1.15-1}{1.15}}$$

$$\text{and } T_{8.75} = 298 \times \left(\frac{p_{8.75}}{p_{15}}\right)^{\frac{1.15-1}{1.15}} = 277.7° \text{ absolute}$$

or in round numbers 5° C.

Thus the diminished pressure at Cerro is equivalent to a lowering of 20° in temperature; and the moisture in the air will correspond to that of − 14° C. at 76 cm. pressure. (+ 6° − 20° = − 14° C.)

From Renauglt's tables we find that at this temperature 1 kg. air contains 1.7 grams water vapor; then the water in the air require to burn 1 kg. of coke at Cerro will be $10.4 \times 1.7 = 17.68$ grams, or nearly 9 percent. of the water contained at the coast.

Thus nearly $\frac{9}{10}$ of the heat units used at sea level, to heat the water of the air blown into the furnace, is saved at the higher altitudes. As the number of heat units at the coast was 112.7 kg.-calories, at Cerro these will be reduced to only 10.1 kg.-calories, leaving 102.6 which are saved to be added to the efficiency of the furnace. Allowing 2.6 calories for the heat necessary to bring the water vapor from 6° to 25°, we shall have, in round numbers, 100 calories to be added to the efficiency of the furnace at Cerro. The corrected efficiency will be:

$$\frac{4{,}426.7 + 100 - 626.1}{7{,}290} = 53\tfrac{1}{2} \text{ percent} = 1{,}215^{\circ} \text{ C.}$$

as compared with an efficiency of 60 percent. at the coast. In other words, if the furnace at the coast smelts 100 tons daily, the same furnace at Cerro, under the best conditions will smelt only 89; for the fuel has lost 11 percent. of its calorific capacity. At this temperature only copper ores that have been roasted, and of which the slags are very fusible, can be smelted.

Let us examine now the effect of a high-pressure blast. Suppose we make our blast 2.19 lb., and assume this pressure is necessary to blow the required weight of air, 10.4 kg. (Eq. 2.).

If we take 1 cu. meter of air at 8.75 lb. and apply an outside pressure of 2.19 lb. ($\frac{1}{4}$ the atmospheric pressure), the cubic meter will be compressed to 0.75 its original volume; this compression generates heat, but as it is gradual, and as the wind-pipe which connects a blower to a furnace is generally long, the heat generated by this compression is lost through the thin iron shell of the pipe, and when the air reaches the furnace it has the same temperature as the sorrounding atmosphere. When the air passes the tuyeres and expands again, practically to atmospheric pressure, for the ore column of our copper furnaces is so low that this factor can be disregarded, the 0.75 cu. meter will not fill its original volume. The heat lost in the compression has reduced its elasticity. In order to get 1 cu. meter in the furnace, we must take 1 meter raised to the 1.4 power, and for any volume v inside the furnace, we require $v^{1.4}$ from the outside. This is an adiabatic expansion:

$$p(v)^{1.4} = p_1 (v_1)^{1.4}, \text{ whence } v = \left(\frac{p_1}{p}\right)^{\frac{1}{1.4}} v_1$$

Equation (4) gives 13.71 cu.-meters of air necessary to burn 1 kg. coke at Cerro. The pressure 2.19 lb., which is $\frac{1}{4}$ the atmospheric pressure, will give us: $13.71 \times \frac{3}{4} = 10.28$ cu. meters air at an absolute pressure of 10.94 lb. Expanding back these 10.28 cu. meters from a pressure of 10.94 (pressure at Cerro, 8.75 + pressure of blast, 2.19) to a pressure of 8,75, we have

$$v'_{8.75} = \left(\frac{10.94}{8.75}\right)^{\frac{1}{1.4}} \times 10.28 = 11.78 \text{ cu. meters of air.}$$

The work of the gases in this expansion is: $W = \frac{p_1 v_1 - p v}{1.4 - 1}$.

Using the metrical equivalent of sea-level pressure we have:

$$W = \frac{10{,}333}{0.4}\left(\frac{35}{48}\,10.28 - \frac{28}{48}\,11.78\right) = \frac{10{,}333}{19.2}\left(35 \times 11 - 28 \times 11.78\right) =$$

29,181.3 kg.-meters; and the heat units, $29{,}181.3 \div 425 = 68.6$ kg.-calories, which makes the relative efficiency:

$$\frac{4{,}426.7 + 100 - 626.1 - 68.6}{7{,}290} = 52.56\% = 1{,}195.5°\text{C.}$$

Thus, 2 lb. of blast additional at these high altitudes have lowered the temperature of the furnace by about 20°.

Let us now compute the efficiency. At sea level the furnace has given as sensible heat

1.6 cu. meters	CO_2,	which	at	1,365°	take up.....	1,463.8 cal.
6.4 "	N	"	"	"	" "	2,962.9 "
0.2 kg.	H_2O	"	"	"	" " nearly.....	112.7 "
						4,539.4 "

$\frac{4{,}539.4}{7{,}290}$ = 62.2 percent. sensible, or temperature-making heat; and not accounted for.

$\frac{2{,}750.6}{7{,}290}$ = 37.8 percent. vanished heat.

Of the 4,539.4 calories obtained as actual heat, some is lost in the escaping gases. Suppose the gases escape at 500°:

$$4{,}539.4 \times \frac{500}{1365} = 1{,}662.8 \text{ cal.} = 22.8 \text{ percent. wasted;}$$

and 2,876.6 " = 39.4 percent. utilized.

Then we have:

2,750.6 cal. vanished as radiation, etc	37.8%
1,662.8 cal. wasted in escaping gases	22.8
2,876.6 cal. available for melting (efficiency)....	39.4
7,290. cal.	100.0

Let us try to find how much ore this furnace will smelt; and to

make the calculation simpler, let us suppose that only slag is produced. Assuming the average copper slag to melt at 1,150°, requiring for this 316 calories and 90 calories more to fuse it, the slag at 1,220°, which is the probable temperature in the cruicible, will take up 419 cal. per kg.; but each kilogram produces around 43.4 calories heat of formation.

If we call x the number of kilograms of slag formed, we shall have:

$43.4\,x$ = heat of formation of x kg. of slag.
2,876.6 = heat available for making x kg. of slag.
$2{,}876.6 + 43.4\,x$ = heat at hand for formation of slag.
$419\,x$ = heat wanted for formation of slag.

Equating, we have:

$43.4\,x + 2{,}876.6 = 419\,x$, whence $x = 7.6$ kg. slag formed.

Smelting matte, the proportion of coke to ore will be more advantageous; and if the proportion is 3 of matte to 7 of slag, 1 kg. of coke will smelt 10 kg. of ore.

Perhaps this treatment of the formation of the slag may be thought arbitrary by many readers; but a moment's reflection will show that the slag and the gases of combustion cannot have the same temperature. As soon as the slag, in our case, rises to 1,150° and gets the 90 calories necessary for its liquation, it drops into the crucible, and whatever excess of temperature it obtains above this is due to the transfer of heat from a hotter to a cooler body. From the nature of the furnace, once the slag is in the crucible, the ratio of temperature between slag and hot gases must be more or less fixed, since the constant tapping of the slag does not give enough time for equalizing the temperatures.

In estimating the efficiency of the furnace in the higher altitude, we will assume that the radiated heat is the same (37.8 percent.).

In the course of this article we have seen that 100 calories are gained by the furnace in the higher altitude, by saving the heating of the water vapor; but there is a loss of 626.1 calories due to the expansion of the gases; thus the net loss is 526.1 calories, or 7.2 percent. Keeping the same relation between the wasted and available heat, we have:

2,750.6	cal.	vanished as radiated heat	= 37.7%
526.1	"	" in expanding gases	= 7.2
1,466.2	"	lost in waste gases	= 20.1
2,544.2	"	available heat for melting (efficiency)	= 34.9
7,287.1			99.9

Equating as before, we have:

$$43.4\,x + 2{,}544.2 = 419\,x;\ \text{whence}\ x = 6.7\ \text{kg. slag.}$$

By roasting and careful fluxing, more fusible slags can be made, thereby increasing the output of the furnace; but this is expensive and only rich ores can stand it. This is what is done by our successful smelters; the ores are very carefully prepared, before going into the furnace; and to have a safe margin of heat, the quantity of coke, as well as of air blown in, is somewhat increased, for we have seen that the temperature of the furnace has fallen from 1,365° to 1,215°, which is not sufficient for the regular operation of smelting copper ores.

It would be tedious to enter further into these details but the calculations already made are sufficient to show that, even with the necessary amount of air, smelting is much more difficult at the Andean altitudes than at sea level; and the man who at these altitudes wishes to work with open eyes must not forget the laws of the expansion of gases.

Let us now apply the same process of reasoning to pyritic smelting, assuming an ore having 70.84% FeS and 29.16% SiO_2.

To make this case as nearly as possible like the one already examined (using coke), we will consider 1 kg. of fuel, which in this case is the ore itself, and suppose it is converted into slag:

From the chemical equation, we have:

$2FeS$	+	$6\,O$	+	SiO_2	=	$(2FeO)\,SiO_2$	+	$2SO_2$
Fe = 0.4508 kg.	+	0.1288 kg.	+	0.2916 kg.	=	FeO–0.5796 kg.	+	S–0.2576 kg.
S = 0.2576 "	+	0.2576 "			=	SiO_2–0.2916 "		O_2–0.2567 "
0.7084	+	0.3864	+	0.2916	=	Slag 0.8712	+	0.5152

From thermophysics, we have:

1 kg.	FeO	gives	912.5	cal.,	whence	0.5796 kg.	will give 528.9 cal.
1 "	SO_2	"	1082.1	"	"	0.5152 "	" " 557.5 "
1 "	Slag	"	43.6	"	"	0.8712 "	" " 38.0 "
						Total.....	1,124.4 cal.
1 kg.	FeS	takes	272.6	cal.,	whence	0.7084 kg.	takes 193.1 "
						Difference.....	931.3 cal.

Thus we have a total of 931 calories to run the furnace.

In coke smelting, the furnace gave a certain distribution of heat, which we will keep, since it will be more or less the same in pyritic smelting; this is:

37.8%	vanishing heat	352.0 cal.
22.8	wasted "	212.0 "
39.4	efficiency or melting capacity	367.0 "
100.		931 cal.

The slag of our equation will heat up and melt with an expenditure of 395 calories per kilogram, and most likely, at the crucible of the furnace, will have consumed 406 calories; thus, $406 \times 0.87 = 353$ cal., is the heat necessary in this case to melt 0.8712 kg. As we have 367 calories in the furnace, there is an excess of heat above what is necessary to run the furnace.

The heat produced is almost equally divided between the Fe which gives the solid product FeO, and the S, which gives the gaseous SO_2. The O necessary to burn these elements is 0.3864 kg., which represents 1.288 kg. additional N, giving 1.6752 kg. of air, or 1.2886 cu. meters.

The gaseous products of combustion are:

$SO_2 = 0.515 \div 2.88 = 0.178$ cu. meters.
$N = 1.2886 \div 1.26 = 1.023$ " "

Total .....1.201 " "

We now have the principal data required to find the heat loses of this furnace working at Cerro de Pasco, at an atmospheric pressure of 8.75 lb. to the inch. The item lacking is the relative radiation between the two pressures; but as it cannot be had, we shall have to approximate its value.

The gases and the solid products of combustion, while gradually losing their temperature in doing the work of heating and melting the slags, will consume, as we have found, 62.2% of the total heat, or 577 calories. If we compute the temperature to which this 577 calories will raise its own products, and then deduct the heat lost by the gases in expanding from 15 lb. to 8.75 lb., we shall have the

sensible, or temperature-making heat which the furnace gives at Cerro.

The products of combustion, as we have seen are: 0.178 cu.-meters SO_2; 1.023 cu. meters N; and 0.5796 kg. FeO, which represent the following calorific capacity:

$$SO_2 = 0.178(0.36\,t + 0.0003\,t^2)$$
$$N = 1.023(0.303\,t + 0.000027\,t^2)$$
$$FeO = 0.58(0.146\,t + 0.000029\,t^2)$$

$$0.000097841\,t^2 + 0.45858\,t = 577$$
$$t = 2{,}325^\circ \text{ C.}$$

Thus the fuel constituents of the ore, if not allowed to lose their heat in melting the slag, would, at sea-level pressure, raise their own temperature to 2,325° C.

To find the value of the work of expansion from equation (5), $PV \log_e \frac{12}{7}$, P and $\log \frac{12}{7}$ will remain the same; the only change will be in V.

Since the values of V are proportional to the absolute temperatures, if we call V_1 the new value of V we shall have:

$$V_1 = \frac{V \times (2{,}325 + 273)}{1{,}365 + 273} = 6 \times 1{,}585 = 9.51 \text{ cubic metres, and:}$$

$$P\,V_1 \log_e \frac{12}{7} = 10.333 \times 9.51 \times 0.5365 = 52{,}720 \text{ kg.-meters}$$

per cubic meter of gas formed. But as there are 1.20 meters, the total work will be:

$$52{,}720 \times 1.20 = 63{,}264 \text{ kg. = meters.}$$

Reducing work to heat, we have: $63{,}264 \div 425 = 148.8$ kg.-calories. Therefore the sensible heat has been reduced by 148.8 calories, and the temperature must be lowered 25.6%.

Making a new distribution of the heat, we have:

37.8%	vanishing heat of radiation and convection	352.0	cal.
14.9	" " " expansion	142.0	"
16.9	wasted " in gases	158.3	"
29.3	melting " (efficiency)	278.7	"
98.9		931.0	"

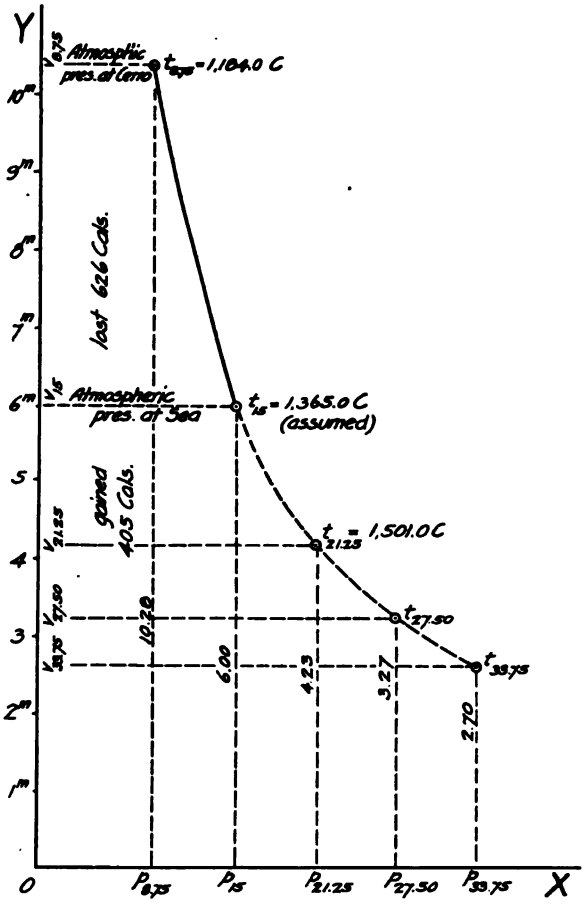
This distribution of the heat is rather arbitrary for the vanishing heat of radiation is kept the same in both cases. Decreased temperature seems to demand decreased radiation; but on the other hand, the decrease in atmospheric pressure increases radiation. Not having data on this point, I have thought convenient to let increased radiation balance decreased temperature; and if the results are not absolutely true, they will, at least, be relatively so. At any rate, ordinary practice confirms that this assumption cannot be far out of the way.

From the new distribution, we see that at the higher altitude, the smelting heat has dropped from 366 calories to 278.7; or, reducing to kilogram of slag, from 420 to 312 calories. With this heat no pyritic copper slag can be melted and made to run.

To secure the heat that would be available at sea level, so as to be able to smelt, we must add about 4 percent. coke with the corresponding amount of air to burn it; but this addition tends to make poor mattes, for at high temperatures oxygen has a very strong affinity for carbon, as is proved by the Bessemer converter, where 2 and 3 percent. carbon is burnt without any great oxidation of the iron through which the air blast is made to pass. To counteract the reducing action of the coke, a great excess of air has to be blown; this excess and the consequent increase of the pressure of the blast, cools the furnace, and to remedy this, more coke has to be added. As a result, I have never seen in Peru a shaft furnace trying to do oxidizing smelting and consuming less than 10 to 15 percent. of coke. In Cerro de Pasco, copper ore containing from 6 to 8 percent. Cu., is reduced to matte of 40 to 45 percent. with an expenditure of from 10 to 12 percent. coke. At Yauly, the same quality of ore was concentrated to 28 or 30 percent. with a minimum of 12 percent.; and in the smaller furnaces through the country, the concentration is only 2 or 3 to 1, with an expenditure of 15 percent. coke and an immense amount of air blown in. In fact, oxidizing smelting in Peru to-day, is nothing but pot roasting carried to fusion at the expense of fuel. This is but natural since the altitude reduces furnace temperatures, as we have seen, by 11 to 25 percent., according to the fuel, quantity of air, and intensity necessary for the operation.

In view of all that precedes, I believe that all efforts to do oxidiz-

ing smelting in the Cordilleras will be useless so long as they are conducted at atmospheric pressure. But if artificial pressure were put on the furnace, and the fuel were forced to burn at higher pressure, not only oxidizing but real pyritic smelting could be done in the Cordilleras as easily as at lower altitudes. If this were aided by a



hot blast, then even ores that at present are thought unfitted for this work could be profitably reduced directly, perhaps with the addition of some coke inside the furnace.

It is true that heavier blowing engines would be required, but although these would have to do more intense work, it is likely that, on the whole, not much more work would be done. At present, the

quantity of hot, unburnt air that escapes up the furnace, due to the small ore columns which are indispensable while working on the present system, must represent a large amount of fuel and power, which, if saved, would be enough to run the heavier machines, while a much cheaper and abundant product would be obtained than at present.

The diagram gives the theoretical temperatures of a furnace at − 6.25 lb. and + 6.25 lb., on the assumption that at sea level the temperature is 1,365° C. From this it will be seen that ores which cannot be smelted at an absolute pressure of 8.75 lb. will be easily smelted at an absolute pressure of 21.25 lb., with the same amount of coke and air used in both cases. In pyritic smelting, on account of the greater quantity of air and the higher temperature necessary for the work, the difference will be still greater in favor of the higher pressure, as we have seen already.

There are several ways of increasing the temperature of a furnace:

(1) Reducing to a minimum the heavy losses of radiation and conduction; men who are going to use a shaft furnace in the Cordilleras should not overlook this point. The crucible and the jackets where the loss is the greatest should receive their special attention.

(2) The direct use of fuel inside the furnace is the readiest and easiest way to increase temperature, but in copper matting, every pound of carbonaceous fuel inside the furnace tends to make poor matte; and poor matte is nothing but a reduction of the output of the furnace.

(3) The use of hot blast. The well-known properties of hot blast make it unnecessary to point out the advantages of its use at high altitudes where the heat losses are so great.

(4) The use of back pressure on the furnace, in such a way that the fuel is forced to be burned at the pressure desired for its most economical working.

The combination of all these conditions favorable to high temperature in a single and easily worked furnace would be the ideal for high altitudes.

ECONOMICS OF MOTOR TRUCKING.—II.

BY CLINTON BRETTELL.*

This installment will present detailed data concerning the relative costs of trucking by horse and by motor in a number of special industries.

Ice Dealers.

The Kane & Trainor Ice Co., Sacramento, Cal., has found motor haulage of ice to be cheaper than horse haulage.[1] The first truck installed had a capacity of three tons and took the place of two teams the year round and an additional team for six months, with a spare team for six months. The truck is used in supplying the wholesale trade, the average length of haul being 20 miles. It hauls 12,600 lb. or about six tons at each load, and averages six loads per day. This means that the truck is over-loaded 100 percent. all of the time. To take account of this over-loading, which can only result in excessive wear, a very high rate of depreciation should be charged. The comparative operating costs were originally stated as follows:

HORSE DELIVERY		MOTOR DELIVERY.	
Repairs:		Repairs and sundries (including complete overhaul)	$1,484.14
2 wagons, 12 months	$ 250.00	Tires	283.92
1 wagon, 6 months	25.00	Labor, (driver @ $4.00 per day, helper @ $2.88 per day) for 365 days per year	2,521.65
Horses; (Storage, feed and care):		Gasoline	228.65
4 for 12 months @ $15.00 per month,	720.00	Lubrication	145.05
2 for 6 months @ 15.00 per month	180.00	Depreciation	269.75
2 for 6 months @ $7.50 per month	90.00	Total cost for one year	$4,933.16
Depreciation on horses and wagons	150.00		
Labor, 4 men for 12 months @ $85 per mo.	4,080.00		
2 men for 6 months @ $85 per mo.	1,020.00		
Total cost for one year	$6,615.00		

This shows an apparent saving of $1,681.84 in favor of the motor for the first year.

* Truck Sales Department, Locomobile Company of America, Bridgeport, Conn., to whom the author is indebted for permission to reproduce much of the information in this article.

[1] *Commercial Vehicle.*

These figures illustrate the errors that appear in many of the published data concerning the relative costs of horse and motor transportation. For instance, under horse costs, no mention is made of interest on the investment. The charge of $15 a month for feeding, storing, and caring for a horse, and also storing the wagon, would actually about pay for feed and nothing more. No account is taken of other items of expense, shoeing, doctoring, loss of horses by sickness or heat, etc. No charge made for harness. Depreciation is extremely low. A truck horse has but a few years of usefulness for heavy work; in this case, the cost of a horse seems to be spread over too many years. A schedule of expenses which would more nearly fit the case is the following:

Yearly mileage of truck (first year)	5,960 miles
Gasoline used	1,500 gals.
Oil used	188.5 gals.
Yearly tonnage of ice	6,716 tons
Actual working days	297
Possible working days	312

HORSE DELIVERY.

1. *Wagon Expense:*

(*a*) Maintenance, grease, repairs, etc.

2 wagons, 12 months	$250.00
1 wagon, 6 months	50.00
	$300.00

(*b*) Depreciation, 10%.

2 wagons @ $350.00 each, 1 year	$ 70.00
1 wagon @ $350.00 for 6 months	17.50
	$87.50

2. *Horse Expense:*

(*a*) Depreciation @ 15%.

4 horses @ $350.00 each, 1 year	$210.00
2 horses @ $350.00 each, 6 months	52.50
2 horses @ $300.00 each, 6 months (reserve)	45.00
	$307.50

(*b*) Proportion that die: 1 in 20 (average). Since in this business, horses have their hardest work in the hottest weather, the loss from death would be even higher, perhaps 1 in 18. This would give 6/18 cost of one horse lost each year, or 6/18 × $350.00 ..... $115.00

(*c*) Stabling. (Feed, water, bedding, blankets, hostler, stable-supplies, rent, etc.)

4 horses @ $25.00 per month for 1 year	$1200.00
2 horses @ $25.00 per month for 6 mos.	300.00
2 horses @ $15.00 per month for 6 mos.	180.00
	$1680.00

(*d*) Veterinary and Medicine		$ 75.00
(*e*) Shoeing @ $3.00 per set, one set per month.		
4 horses, 1 year		144.00
2 horses, 6 months		36.00
2 horses, 6 months (reserve)		10.00
		$190.00
3. *Harness Expense:*		
(*a*) Depreciation @ 10%		
2 double sets @ $75.00 each, for 1 year	$ 15.00	
2 double sets @ $75.00 each, for 1 year, (used 6 months)	5.00	
	$ 20.00	
(*b*) Maintenance and repairs	$ 25.00	
4. *General:*		
(*a*) Interest on investment @ 5%.		
4 horses @ $350.00 for 1 year	$ 35.00	
(Average taking account of deprec. of capital)		
2 horses @ $350.00 for 6 months	8.50	
2 horses @ $300.00 for 6 months	7.50	
	$51.00	
5. *Drivers' Wages:*		
4 men for 12 months @ $85.00	$4080.00	
2 men for 6 months @ $85.00	1020.00	
	$5100.00	
Total cost of horse delivery	$7951.00	

In the case of motor delivery also, some items were omitted in figuring costs. Interest was not considered. Tire costs are low. No charge is made for garage, garage help, etc. A more accurate analysis would be the following based on actual average operating costs for 3-ton trucks:

MOTOR DELIVERY.

1. Repairs and sundries (including complete overhaul)	$ 500.00	
2. Tires (about $70 each or $420 per set (for 8000 miles @ 5,690 miles per year)	315.00	
3. Labor (driver @ $4.00 per day, helper @ $3.00 per day) 312 days per year, $1248 + $936	2184.00	
4. Garage (including light, heat, rent, help, etc., $25.00 per month)	$ 300.00	
5. Interest (average yearly rate @ 5% on $3600)	87.50	
6. Gasoline (4.5 miles per gal.) 1260 gal. @ 18c.	227.00	
7. Oil and lubricants:		
Oil, 150 miles per gal. @ 40c	16.00	
Grease	14.50	
	$ 30.50	
8. Depreciation, 15% on $3500.00	$ 525.00	
9. Taxes, insurance, etc.:		
Fire, 1¾% of $2870	50.00	
Liability	85.00	
Taxes, etc.	15.00	
	$ 150.00	
Total cost of motor delivery	$4319.00	

The saving shown by these revised figures is $7,951 - $4,319 = $3,632.00 per year, the price of a new truck.

Lumber Dealers.[2]

Comparative costs by truck and horse are as follows:

	5-ton truck.	2-horse team.
Total investment with equipment	$5,362.12	$1,510.00
Total expense per day (insurance, interest, depreciation, upkeep, repairs, etc.)	15.26	5.63
Average mileage per day	42.50	15.00
Average round trip haul, miles	5.00	5.00
Average number of trips per day	8.50	3.00
Average load, dressed lumber	5,000 ft.	2,500 ft.
Average weight per load	5 tons	2.5 tons
Total per day	42,500 ft.	7,500 ft.
Total expense per 1000 ft. lumber	$ 0.36	$ 0.75

The truck was equipped with a roller body, and had a 4-wheel loading wagon for gathering lumber around the yard, as an accessory. It required three minutes to transfer the load to the truck, and two minutes to unload without damage to the lumber. By means of these devices for saving loading and unloading time, the motor truck is able to step into this kind of work and show a saving in the cost of hauling lumber over the old horse-wagon methods.

Brick Dealers.[3]

Loading and unloading devices in the brick business have made it possible to keep the truck in motion a large portion of the day, with corresponding economy. The bricks are piled on cross-planks, these planks resting on stands which are long planks placed on edge, parallel, and all joined to a base. The skip, a fork-like device with long fingers, is lowered and then entered into the spaces between the planks. When the skip is raised, it picks up the cross-planks and the bricks piled upon them, 840 bricks to a unit, weighing about 3350 lb. The reverse operations take place in depositing the bricks in the truck body, the fingers passing down between upright planks of body, leaving behind the cross-planks and their load of bricks. The skip can then be withdrawn. Three of the units make up a 5-ton load, or about 2520 brick. To unload the brick, the body is dumped

[2] *Commercial Car Journal*, Dec. 15, 1912.
[3] *Power Wagon*, Dec. 1, 1912.

in the usual way. For pressed brick, however, this method of dumping is too injurious and other means have been devised.

With the skip described above, loading can be accomplished in less than 1 min. per unit, or about 5 min. per load of three units. Unloading is complete in 5 min. by means of the dump body. Compare this with the time for hand unloading and loading: One man, hand tossing, can pass 1500 brick in 20 min. or 2500 brick in 34 min. The power loading device required two men at the kiln, who received less than 15c. per 1000 brick. Unloading was performed by 1 man. The cost of loading was $\$0.15 \times 2.5 = 38c.$ for labor, and about 5c. charged against use of machine.

Following is the record [4] of a demonstration for a brick company by a 5-ton gasoline truck, first over a short haul with radius of 3.8 miles, later over a long haul with radius of 8.3 miles.

Short Haul — Average Radius, 3.8 Miles.

Date	Time in Service		Mileage	Brick Delivered
July 10	7 hr.	58 min.	18	7,500
11	10	47	51	22,500
12	9	15	42	17,500
13	4	57	15	7,500
15	10	35	44.5	17,500
16	5	2	27	10,000
17	7	1	35	15,000
18	7	25	33.4	12,500
20	2	36	16.7	5,000
22	6	27	31.4	10,000
23	8	42	46.5	12,500
24	8	10	41.8	12,500
25	8	26	41.2	12,500
26	9	20	48	12,500
27	7	25	38.8	12,500
29	11	55	85.9	12,500
Total	126 hr.	1 min.	616.2	200,000
Average	7	52	38.5	12,500

[4] *Power Wagon*, Dec. 1, 1912.

Long Haul — Average Radius, 8.3 Miles.

Date	Time in Service		Mileage	Brick Delivered
Aug. 2	10 hr.	55 min.	81.8	10,000
3	9	20	64.8	10,000
5	10	40	92.2	12,500
6	11	4	81.5	12,500
7	10	6	73.4	10,000
8	9	55	49.5	10,000
9	2	25	17.5	2,500
10	7	45	49.5	7,500
12	9	20	67.5	10,000
13	10	0	53.8	10,000
Total	91 hr.	3 min.	631.5	95,000
Average	9	9	63.1	9,500

COST OF OPERATION, 5-TON DUMP BODY.

Investment in truck		$5,000
Interest @ 5% per year	$ 250.00	
General insurance	175.00	
Garage @ $12 per month	144.00	
(This does not pay for washing and polishing as driver does this himself.)		
Driver @ $20 per week, 50 weeks	1000.00	
Fixed charges per year		$1569.00
Fixed charges per day (300 working days)	5.23	
Operating charges, per mile:		
Tires, 8000 miles @ $488.95		$0.06110
Gasoline, 4½ miles per gal. @ 10c. (? very low)	.02200	
Lubrication:		
Motor, 250 miles per gal. @ 50c.	.00240	
Transmission, 1,000 miles per gal. @ 65c.	.00065	
Rear axle, 1000 miles per gal. @ 65c.	.00065	
Allowance for daily repairs and overhaul (maintained and overhauled at 15,000 miles)	.03500	
Depreciation @ 150,000 miles	.02870	
Total operating expense per mile		$0.15050

From the above data, the cost of hauling 200,000 brick can be computed as follows:

Short haul, average radius 3.8 *miles.*— $5.23 × 16 + $0.1505 × 616.2 = $83.70 + $92.80 = $175.50. Cost per 1000 brick = $176.50 ÷ 200 = $0.88.

Long haul, average radius 8.3 *miles.*— $5.23 × 10 + $0.1505 × 631.5 = $52.30 + $95.00 = $147.30. Cost per 1000 brick = $147.30 ÷ 95 = $1.55.

Comparing these costs with the charges for horse-haulage, which are as follows per 1000:

Under 2-mile haul	$1.20
Under 3-mile haul	1.35
Under 4-mile haul	1.50
About 8-mile haul	2.10

we find the saving in the cost by motor on the short haul is $0.62, or 41.4 percent.; while on the long haul it would be $0.55, or 26.2 percent. Actually, the latter haul would never be attempted with horses.

In the above case, the truck did not work regularly 10 hours per day, although under normal conditions the work might be so arranged that it could do so. Assuming that the truck were kept at work 10 hours per day, six days per week, making seven trips of 3.8 miles radius per day, and hauling 17,500 brick per day, in the same manner as above the cost per 1000 brick can be computed as $0.758, as against $0.88. Similarly, for the long haul of 8.3 miles radius, making five trips per day, and hauling 12,500 brick per day, the cost per 1000 brick would be $1.42, as against $1.55 above.

Even better daily capacities, with consequent reductions in cost, can be obtained by avoiding unnecessary delays.

The following table is based on the assumption that a truck would work on an average 9¼ hours out of a 10-hour day, and that it would have an average running speed of 10 miles per hour; loading time, 10 min.; unloading time, 5 min.; body equipped with power hoist.

Radius of Haul, Miles	Average Loads per Day	Miles per Day	Brick Hauled per Day	Cost per Day	Cost per 1000 Brick
1	20	40	50,000	$11.00	$0.22
2	14	56	35,000	13.65	.39
3	10.8	65	27,000	14.85	.55
4	8.8	70	22,000	15.62	.71
5	7.4	74	18,500	16.28	.88
6	6.4	77	16,000	16.64	1.04
7	5.6	78	14,000	16.94	1.21
8	5.0	80	12,500	17.25	1.38
9	4.5	81	11,250	17.32	1.54
10	4.1	82	10,350	17.52	1.71

Comparing team rates with the above we find:

Radius of 2 miles, motor saves	67.5%
" " 3 " " "	59.3
" " 4 " " "	52.7

This shows trucks to the best advantage in short haul work, as opposed to the common idea that trucks are economical only for long hauls. One reason is that the rates for hauling brick by teams are arbitrarily fixed, without any scientific basis. The real explanation, however, lies in the fact that the truck is kept in almost continuous operation by means of time-saving loading devices.

Professional Truckers.

The use of motor trucks in this work, while comparatively new, is growing by rapid strides. The fields from which professional operators of motor deliveries are securing their business is two-fold: (1) From the railroads, for distances up to 40 or 50 miles. (2) Horse and wagon deliveries, which is the source of the greater part of the business. Of 75 motor-wagon professionals in Chicago, over 65 have graduated in part or wholly from the horse trucking business. It is well that this is so, since these men know the streets, the traffic conditions, loading and unloading facilities of their customers, etc., and all this knowledge need not be gained again at the expense of much trouble and inconvenience.

It is a known fact that the cost of horse operation is constantly increasing. (See Table II, p. 246, April issue.)

A steady rise is occurring in both feed and labor expense. The motor truck reduces labor and hence the total labor cost. To be sure, cost of fuel is increasing, but fuel is only used while the truck is in operation, whereas feed expense keeps on whether the horse is working or not. To offset this increase in fuel cost is a constant decrease in tire charges, due to better quality of tires, better roads, and lower initial cost. It is also likely that before long it will be possible, by the use of properly designed apparatus, to utilize cheaper grades of fuel; hence increase in fuel cost is only temporary and is partially, if not wholly, offset by decrease in tire cost.

As a comparison between charges for horse and motor haulage in and around Chicago, consider the following tables.[5]

[5] *Power Wagon*, Dec. 1, 1912, p. 144.

HORSE HAULAGE — CHARGES IN CHICAGO.

Minimum Scale — Maximum Weights.

Type	Per Hour	Per Day	Per Week	Load		
				Nominal	City	Depot
Single Wagon	$0.60	$ 4.50	$21.00	1 ton	2,500	3,000
½ "	.70	5.00	28.00	2 "	4,500	5,000
Double "	1.00	6.00	30.00	3 "	6,000	7,500
3-horse "	1.25	8.00	39.00	4½ "	9,000	11,000
4-horse "	1.50	10.00	48.00	6 "	12,000	14,000

Straight time for overtime up to 10 p. m. at barn. Time and a half from 10 p. m. to 6 a. m.

To show how closely the motor operators figure in fixing their rates, consider the following costs for a 5-ton and a 3-ton truck, and compare them with the rental charges of the Star Company, of Chicago.

Daily Cost.—

	5-ton	3-ton (4-ton load)
Depreciation, 20% per year	$ 2.74	$ 2.19
Interest @ 6%	.82	.65
Insurance	.48	.42
Taxes	.15	.10
Garage	.50	.50
Tires	3.00	2.50
Upkeep (including yearly overhaul)	1.00	1.00
Gasoline	2.00	2.25
Cylinder oil and lubricants	.26	.55
Driver	3.00	3.00
Total per day	$13.95	$13.16
Average load, pounds	10,600	8,000
Average daily mileage	50 miles	50 miles
Cost per ton-mile (full load ½ way)	$0.112	$0.132

Daily Rental Charge, Star Company.—

Capacity	Daily Rental	Operating Cost	Profit per Day
1 ton	$12.50		
1½ "	13.25		
2 "	14.00		
3 "	16.00		
4 "	17.25	$13.16	$4.10
5 "	18.50	13.95	4.55
6 "	20.00		
7 "	21.00		
10 "	25.00		

Driver, $25 per week; helper, $24 per week; overtime, 45c. per hour; vacation with full pay.

Brewers.

The Feigenspan Company, of Newark, now has 11 trucks with a total capacity of 62 tons.[6]

Of the company's present business, 40 percent. is new and was secured directly through the use of motors. The hauls are long, averaging 40 to 45 miles per day. Two trips daily are made, delivering 4,400 cases or 1,320 barrels, picking up empties on the way. The trucks are used in suburban delivery only. They were found to be cheaper than horses in spite of several conditions which operate against them; for instance, the labor unions require two men to go out with each truck where one would be sufficient.

Produce Dealers.

H. T. Pierce, of Detroit, Mich., was one of the first to introduce motor trucks for large-scale delivery of produce.[6] His 3-ton truck is in service 14 to 17 hours per day. It starts out at 1:30 a. m. and before 9 a. m. has delivered three carloads to wholesale markets. The remainder of the day is spent in delivering to retail dealers. Formerly two double teams and three single wagons were used to do the same work. Its great advantage, even more important than its economy, is the speedy deliveries of perishables, fruits, etc.

Conclusions.

From the figures given in the preceding pages, it appears that the field to which horse trucking is adaptable is limited to cases in which the mileage is low, delays are frequent, loading and unloading facilities are poor. Hence, for most work, it is safe to assume that if it can be done at all, it can be done best by some type of motor truck. Thus, the question is narrowed to a choice between electric and gasoline motors.

Consulting the curves in Chart II (p. 251, April issue) we note that there is a fairly distinct division between gasolines and electrics, the latter being limited to a daily mileage of about 35 miles, assuming but a single battery charge per day. Higher mileages are claimed for some of the smaller capacity trucks, but for the present this is a safe limit to fix.

Here, then, are the fields to which each is best adapted. The elec-

[6] *Commercial Vehicle*, Oct. 1912.

tric for city work, with its frequent stops and delays and comparatively low mileages; the gasoline truck for suburban and interurban transportation, where the ratio of idle time to running time is a minimum. Of course, there is no fixed dividing line between the two. In fact, a glance at the curves will show that the gasoline truck is more economical than the electric trucks except for extremely low mileages. On the other hand, electric trucks have been used advantageously for comparatively long hauls. But on the whole, the above division is a safe one to make.

All of the foregoing applies to average conditions only, and by no means implies that some other form than that indicated may not be more economical, or perhaps even imperative under certain peculiar conditions. Thus, there are numerous cases in which the horse-drawn vehicles give the cheapest and best service. As a rule, however, this is due to the fact that the truck is hampered in its operation, by poor loading or unloading facilities or other faults which are inherent in the business and are in no wise chargeable against the motor truck.

In figuring wagon-transportation costs, also, it very often happens that some important item is entirely lost sight of: rent, because the proprietor owns the stable; a charge for superintendence and care, because he himself attends to this; depreciation, because that is such an intangible thing; and many others. Such erroneous calculations will often show marvelous advantages in favor of the horse. But gradually proprietors of businesses which have to rely on the transporting of goods are beginning to realize that precise and accurate cost keeping is just as important in this branch of their business as in any other.

Another source of much trouble is the haphazard way in which goods to be transported are handled in the establishment itself. Shipping facilities are often inadequate, the product reaches the shipping room in a confused jumble, addresses are carelessly written, and many other difficulties are present to cause delays. More often than not, then, the truck salesman's first task is to go into the purchaser's establishment and rehabilitate his entire shipping and routing system. In other words he must be an efficiency engineer. What better work could an engineer choose for himself than the solution of this problem of transportation?

THE BY-PRODUCTS OF SUGAR MANUFACTURE AND METHODS FOR THEIR UTILIZATION.*

BY C. A. BROWNE.†

Lectures delivered in previous years before the students of this course took up the "Chemistry of Raw Sugar Production"[1] and the "Manufacture of Raw Sugar in the Philippine and Hawaiian Islands."[2] Since these lectures have been printed in the SCHOOL OF MINES QUARTERLY, I will avoid repetition and save time by referring you to this journal for particulars regarding the chemical composition of sugar cane and the sugar beet and the methods of manufacturing raw sugar. As a subject for this lecture it appeared to me that a discussion of the by-products of sugar manufacture and methods for their utilization would fill up certain gaps that were not covered in the previous lectures, and so help to give us a broader survey of the sugar industry as a whole.

It may be stated as a general rule of all manufacturing that the number of by-products and the means for their utilization increase with the improvements in technical processes. This is particularly the case with the sugar industry. In the Philippine Islands we saw that the juice of the sugar cane was evaporated to a solid mass of concrete sugar which contained not only the sucrose, but the invert sugar, salts, amids, gums and other soluble ingredients of the cane.

Another example of raw sugar which contains the soluble impurities of the juice is the semi-liquid Jamaica sugar, which is sold in Kingston by the quart. When sugar is made by such primitive methods, there are no by-products and the question of their utilization is therefore a superfluous one.

The by-products of sugar manufacture in the more progressive countries are so numerous that it is possible to cover the field of their utilization only in the most superficial manner. In treating our

* A special lecture in the Department of Chemistry, Columbia University, April 28, 1913.

† Chemist-in-charge, New York Sugar Trade Laboratory, 80 South St., New York.

[1] SCHOOL OF MINES QUARTERLY, April, 1911.

[2] *Ibid.*, January, 1913.

subject we shall find it in many ways more convenient to sub-divide it according to the character of by-product, as follows:

1. The utilization of the cellular refuse of beet and cane.
2. The utilization of the impurities removed in clarification.
3. The utilization of the waste molasses.

Utilization of the Cellular Refuse of Beet and Cane.

In discussing this topic, we must bear in mind the differences between the physiological structure of these two plants, and also the differences in method of extracting the sugar.

The sugar beet is a pulpy root growing under ground. In harvesting the crop, the beet is dug up and the leafy top, together with the crown of the beet, cut off, after which the beets are transported to the factory. The leafy tops of sugar beets constitute a very important by-product which is usually utilized as a cattle food. In some cases, the beet leaves are simply dried, either in the open air if the weather permits, or else by mechanical driers; the dried leaves have the fragrance of the best hay and are much relished by farm animals. In many cases the beet leaves are converted into ensilage; the wilted leaves are tightly packed in silos and covered with earth to exclude the air; a lactic fermentation takes place which converts the tops into a sour fodder something of the nature of sauerkraut. Access of air must be prevented; otherwise putrefactive changes take place with formation of butyric acid and other decomposition products which give the ensilage a most unpleasant odor.

The pulp that remains in the diffusion batteries after washing out the sugar from the sliced beets forms another very important by-product which is also used for feeding cattle. If there is a large cattle farm or ranch near the sugar factory, the wet pulp can be fed out just as it is emptied from the diffusion cells. The farmers who supply a sugar factory with beets frequently stipulate for a return of the beet pulp for feeding purposes, and a considerable amount of the pressed pulp is sent out from the sugar factories in freight cars, frequently to a distance of 50 or even 100 miles. In many cases the beet pulp is converted into ensilage and fed out to the stock according to requirement. The same precautions as to the silo must be followed as in making beet-leaf ensilage.

When local conditions are unfavorable for feeding the pulp or converting it into ensilage, many factories dry the pulp, using for this purpose the heat of the flue gas escaping from the boilers. The dried beet residue consists of a crisp brittle material which is packed in bags and sold as a cattle food; it is much relished by farm animals. Dried beet pulp swells up enormously when wet, so that care must be exercised not to permit animals to gorge themselves and then drink an excess of water. Death of live-stock has resulted from neglect of this precaution.

In the cane sugar industry a large amount of waste cellular matter also results from the harvesting and milling of the crop. The leafy portion of the cane top is sometimes fed to farm animals, and it has aslo been proposed to convert this material into ensilage, although I know of no such utilization upon an extensive scale. The green tip of the cane stalk, which is removed with the leaves in harvesting, is valueless for sugar making but is utilized for seed in most tropical countries, as stated in the last lecture. In Louisiana, owing to the limited period of harvest and the haste to get the cane all pressed before winter, no time is available for utilizing the cane tops; they are therefore left upon the ground and are afterwards burned.

The bagasse, or cellular matter of the cane stalk, which is left after milling, is a very important by-product and many schemes have been proposed for its utilization. In most cane-producing countries the bagasse is used as a fuel to supply steam for the engines and heat for the evaporators. In many places the bagasse is the only supply of fuel available, and when this is the case other methods of utilization are impracticable. Bagasse, as it leaves the cane mill under good systems of extraction, contains about 50 percent. moisture and in this condition has a fuel value about one-quarter that of soft coal. The employment of bagasse as fuel has appeared to many a very wasteful procedure, and attempts have been made to use it in the manufacture of paper. It is obvious, however, that this method of utilization can be considered only when the value of bagasse as paper stock exceeds its value as fuel.

It has been demonstrated that paper of very excellent quality can be manufactured from bagasse, although the cellular structure of the cane may involve a considerable loss of cellulose, if the same

methods of manufacture are followed as are employed with wood, straw, and other materials of coarse fiber. The cellular substance of sugar cane is very much like that of corn stalk and consists of about 75 percent. of fibrous cells and 25 percent. of pithy cells, the latter constituting the sugar-bearing tissue of the cane. The pith cells lack the felting property of the fibrous tissue; they are very easily disintegrated in the soda or sulphite digestion, which is ordinarily used in paper manufacture, and unless care is exercised are completely lost in the wash water. It was held at one time that the pithy tissue was valueless for paper making; this, however, is not the case. Cellulose made from the pith, while devoid of felting properties, has strong adhesive qualities upon drying out. Paper can be made, in fact, from the pith alone, and the product thus obtained has a strong resemblance to parchment in appearance and toughness. While the very best paper can be made from bagasse, but very little sugar-cane fiber is utilized at present for this purpose. The chief obstacles seem to be the great value of bagasse as fuel and the difficulty of securing skilled labor in the tropics.

Under good conditions of manufacture, four tons of wet bagasse will give one ton of paper, the value of which we may place at $20. Since four tons of bagasse equal one ton of coal for heating purposes, me may put the fuel value of this bagasse at $3, although this figure is much greater in countries where there is no coal supply. The value of bagasse, using the above figures, is therefore over six times greater for paper than for fuel. This ratio is reduced considerably, however, when we take into account the interest upon investment and the depreciation in value of the paper plant, as well as the direct cost of making the paper.

In this connection mention should be made of a new process which is being tried at present, which, if successful, promises to revolutonize present methods of sugar manufacture. This process consists in shredding the cane near the fields where it is cut, drying the shredded stalks, pressing the substance into compact bales, and shipping it to factories in the United States or elsewhere. The dry material is there extracted with water in diffusion batteries, and the sugar which is washed out is manufactured directly into refined sugar. The residue of fiber, in another department of the same factory, is

made into paper. The promoters state that the paper is the product of most value from this process, the sugar being thus reduced in importance to a by-product. The sugar world is watching the developments of this new experiment with great interest.

UTILIZATION OF IMPURITIES REMOVED IN CLARIFICATION.

The quantity of filter-press cake obtained in sugar manufacture varies greatly according to the amount of lime and other agents used in clarification, and according to the purity of the juices. The amount of wet press-cake obtained in Java by the ordinary process of defecation was found to be about 1 percent. of the weight of cane; the press-cake contained about 70 percent. of moisture and 10 percent. of sucrose, whence the actual amount of impurities removed from the juice is only about 0.2 percent. of the weight of the cane. The material consists of fine particles of bagasse ground off in milling, with an admixture of wax, proteins, gums, lime sulphate and phosphate, iron oxide, and alumina, and considerable earthy matter which was brought in on the cane stalks from the field.

Where the carbonatation process of clarification is used, as is the case with beet-sugar manufacture, the press-cake is mostly calcium carbonate, the remainder consisting of the wax, proteins, gums, etc., found in defection press-cake.

Great benefit has been derived from the use of filter-press cake as a fertilizer, the nitrogen existing in a form which is readily available. The excess of calcium carbonate in carbonatation cake has also been found beneficial upon certain soils. The employment of press-cake as fertilizer is about the only means of utilization, although attempts have been made in Java to use the cake from sugar factories as a source of wax. The percentage of cane wax in dried press-cake from the defecation process varies from 10 percent. to 20 percent. To obtain this wax, the press-cake is dried in the sun or by heat of the flue gas, and extracted in percolators by means of naphtha; the latter is then distilled off for re-use and the residue of crude wax is purified by bleaching with chlorine. Sugar-cane wax is a hard brittle substance, resembling carnauba wax in appearance, and can be used as a substitute for the latter for many purposes. The present low price of wax has prevented this method of utilizing press-cake from making any dvancement.

Utilization of Waste Molasses.

The word molasses has many shades of meaning; chemically speaking, we may consider it as the sugar factory mother liquor from which a part of the sucrose has been crystallized. The molasses from the first crystallization may yield, upon evaporation, a second crop of sugar crystals, and the molasses from this may even yield a small amount of impure third sugar. The approximate average composition of beet and cane molasses, from which no more sucrose will crystallize, is given in the following table:

	Beet Molasses		Cane Molasses	
Water	20.00		20.00	
Sucrose	50.00		30.00	
Invert sugar	Trace		30.00	
Salts	10.00	(5% K_2O)	8.00	(4% K_2O)
Nitrogenous substances	10.00	(2% N)	2.00	(0.4% N)
Gums, acids, etc.	10.00		10.00	
	100.00		100.00	

It is seen from the table that beet molasses is distinguished from cane molasses by a higher percentage of sucrose, by a much higher percentage of nitrogenous substances, and by a comparative absence of invert sugar. By treating beet molasses with the hydroxides of calcium, strontium, or barium, it is possible to precipitate the residual sucrose as an insoluble saccharate which, after filtering from the salts, nitrogenous matter and other impurities, is decomposed with carbon dioxide and the sucrose recovered in a pure form. In European countries a number of establishments make a special business of buying up beet molasses and recovering the sucrose by the strontium or other saccharate process. These technical processes of desaccharification belong, however, to sugar manufacture and we will not consider them as pertaining to by-products.

The table shows 5 percent. of potash and 2 percent. of nitrogen in beet molasses and 4 percent. of potash and 0.4 percent. of nitrogen in cane molasses; these figures suggest at once that molasses might have some value as a fertilizer; and such in fact has been demonstrated to be the case upon certain kinds of soil, more especially those deficient in humus. The application of molasses to other soils, however, has caused an acid fermentation with souring of the soil and loss of fertility, so that this method of utilizing molasses is not

uniformly successful. But the greatest objection against this use of molasses is its wastefulness. There are more profitable methods of using the sugar and other organic solids of molasses than employing them as a supply of humus.

A second use for molasses is as a fuel. Molasses containing 20 percent. moisture has a thermal value about $\frac{3}{8}$ that of coal. By means of specially constructed furnaces it is possible to secure a perfect combustion of the carbonaceous matter of molasses, 8 lb. of molasses supplying the same heat as 3 lb. of coal. A residue of ash, very rich in potash, is left and this can find a use either as fertilizer or as a raw material for making potash salts.

Molasses, as we have seen, contains 50 percent. or more of sugar, and the use of such a valuable food material as a fuel is wasteful if other more profitable means of its disposal are available. Unquestionably the most perfect utilization of molasses is as a food. The odor of beet molasses is enough to convince one that it is unfit for human consumption. Waste cane molasses is much more palatable, and many manufacturers of sirups make a business of bleaching it for table use. The exhausted molasses of cane sugar factories, with its accumulations of salts and other impurities, is not, however, a desirable article for sirup, and its use, whether bleached or blended, as a human food is not favored for this reason. Horses, mules, cows, and sheep, on the other hand, eat cane and beet molasses with great relish, and its use as a stock food, whether for working animals, for milk production, or for fattening, is attended with splendid results, provided over-feeding is avoided, which might cause derangement of the digestive system. The higher percentage of salts in beet molasses renders it somewhat less desirable as a cattle food than cane molasses.

The stable manure from animals fed upon molasses contains the valuable potash and nitrogen of the latter, and the use of such manure as a fertilizer has all the advantages and none of the disadvantages which result from the direct application of molasses to the soil.

Molasses is often fed in the liquid form, being either poured into troughs or sprinkled upon fodder. If it is desired, however, to market the molasses as a stock food, its use in the liquid form is attended with several disagreeable features. Molasses is not a con-

venient material to transport or store, and the stock raiser also has difficulty in handling it when compounding his rations. Another objection is that animals become smeared and flies are attracted. To overcome the difficulties just named, it is the usual practice at present to mix the molasses with an absorbent filler, a sufficient quantity of the latter being used to keep the feed dry and free from stickiness. The filler used for this purpose should have not only a high absorptive power but also some nutritive value of its own. Finely cut hay and fodder are examples of such fillers; bran, meal, hulls, chaff, and similar products are also used. Peat and sawdust have been employed as molasses absorbents but such substances are objectionable on account of their low digestibility.

From the sugar manufacturer's viewpoint, the dried leaves and pulp of the sugar beet and the bagasse of the sugar cane make most excellent and convenient materials for preparing molasses feeds. By combining them with molasses in suitable proportions a successful utilization of two by-products is accomplished in one operation. A cattle food called molascuite, consisting of bagasse and sugar cane molasses, is shipped from the British West Indies to England in large quantities. Molasses alone in combination with a filler does not make a well balanced ration, so the usual practice is to incorporate with these a certain amount of corn, cotton-seed meal, brewers' grains, etc., to supply any deficiency in fat or protein. The percentage of molasses in mixed molasses feeds, according to analyses by Halligan, varies from 10 to 60 percent. If more than 25 percent. of molasses is used the feed must be heated in driers to remove the excess of moisture, which should not exceed 12 percent. If too much moisture is present the feed becomes sticky and is very liable to spoil through fermentation.

One of the most common methods of using molasses is the manufacture of alcohol and rum. In many tropical countries the sugar house and distillery are side by side, and the chemist is required to have a practical knowledge of fermentation and distilling as well as of sugar manufacture.

In manufacturing alcohol from molasses, the latter is first diluted to a sugar content of about 12 percent. This solution, or "wash," is usually acidified slightly with sulphuric acid to prevent the growth

of injurious bacteria, and then, after adding yeast, is fermented until no further decrease in density is observed. The fermented liquid is then distilled and the alcohol or rum collected in receivers.

To secure the highest yield of alcohol, the temperature of the fermenting liquid should not exceed 30° C. (or 86° F.). In tropical countries, where the temperature of the atmosphere often exceeds this figure, the control of temperature during fermentation is often a difficult matter. A wash containing 12 percent. of sugar and started at 30° C. may, through the heat liberated during fermentation, reach a temperature over 40° C. Such temperatures in fact do occur in badly managed distilleries with great loss in efficiency from vaporization of alcohol and impairment of the vitality of the yeast. To prevent overheating of the fermenting liquid it is necessary to equip the vats with coils through which cold water can be circulated.

Two gallons of cane molasses should give a yield of one gallon 180-proof alcohol (90 percent. strength) which is the usual standard for denaturing. Such alcohol, according to the last quotations, has a commercial value of 38c. per gallon. The cost of manufacture may be set at 8c. a gallon, which leaves 30c. as the value of the raw molasses, or 15c. per gallon. Sugar-cane molasses in tank cars, according to the last New Orleans quotations, has a commercial value of 6c. a gallon, so that there is a profit of about 9c. a gallon in operating a molasses distillery, provided the output of denatured alcohol finds a ready market, which at present is not always the case. The present high price of denatured alcohol prevents its competing with gasoline, and other petroleum products, as a source of power, light, or fuel.

In tropical countries the distiller of molasses must turn his attention almost entirely to the manufacture of rum. A good quality of rum, containing 80 percent. alcohol, will usually net the distiller over 50c. a gallon. In the Island of Jamaica, which is noted for its rum, I was informed that it takes about 15 lb. of sugar in molasses to make one gallon of rum. This is equivalent to a return of over 3c. a pound on the uncrystallized sugar of the molasses, a value often higher than the return upon the crystallized sugar.

Although we may not advocate its use as a beverage, rum is a commercial product which the food chemist is called upon to in-

spect, analyze, and in other ways to reckon with. A few words may therefore be devoted to the methods peculiar to rum manufacture. Rum is valued not simply by its alcoholic content but also by its flavor. The production of flavor is in fact one of the chief objects of the rum distiller, and a peculiar mystery often shrouds this phase of the process. As an example of the manner in which high-flavored rums are produced, the following process, as used in Jamaica, will be described.

The flavor of rum is due to the presence of alcoholic esters of acetic, butyric, and other higher fatty acids; the first requirement in the production of flavor is the formation of the acids for esterification.

Acetic acid is prepared by allowing cane juice, skimmings from the clarifiers of the sugar house, and other refuse, to undergo an alcoholic fermentation, and then pumping the liquid on to cane trash in cisterns. An acetic fermentation sets in, just as when cider is poured over shavings in the quick vinegar process, and the solution becomes strongly acid.

For the production of butyric, caprylic and the other fatty acids, a putrefactive fermentation is necessary, and this is carried out by dumping the dead yeast from the stills, cane refuse, lees from the retorts, and other adventitious matter, into a receptacle called the "muck hole." A putrefactive fermentation sets in with formation of butyric and other fatty acids. To neutralize the excess of free acid, which would retard fermentation, powdered marl is added from time to time. When the liquid in the muck hole is ripe, it is added to the acid cisterns, the free acetic acid thus liberating the butyric and other acids from their lime salts. The mixture of acids, thus produced, constitutes the basis for flavor production.

In conducting the fermentation, the wash is prepared by mixing molasses, skimmings, and cane juice with a certain amount of "dunder," which is the spent liquor obtained from the stills after distillation. The dunder is rich in nitrogenous compounds and salts, and serves as a nutrient for the growth of the yeast. After fermentation has begun, a requisite amount of the acid flavoring mixture is added; a part of the alcohol, formed by the action of the yeast upon the sugars, unites with the acids of the flavor to produce ethyl ace-

tate, ethyl propionate, ethyl butyrate, and the other higher esters, all of which, passing over with the alcohol when the wash is distilled, give the resulting rum its characteristic aroma and flavor. High flavored Jamaica rum may contain as high as 1 or 2 percent. of esters, while the low flavored rums contain less than half of this amount. Over 95 percent. of the esters consists of ethyl acetate; the remainder is principally ethyl butyrate, the ester of chief importance as regards flavor production, with small amounts of other fatty acid homologues.

Leaving now the manufacture of rum, we will close our subject by considering briefly some of the methods for utilizing sugar-beet molasses. Germany has made the greatest advancement in this regard. Of a total production of 400,000 tons of beet molasses in Germany, about 55 percent. is desaccharified for sugar production, about 30 percent. is used as a cattle food, about 10 percent. is fermented into alcohol, and the remaining 5 percent. is utilized in various miscellaneous ways. Among the latter we may mention the use of molasses for manufacturing dye stuffs, shoe blacking, yeast, moulds and briquettes, and numerous other commodities.

The residues from the desaccharification factories, best known under its German name of molasses *schlempe* has been a subject of special study from the standpoint of utilization. If we subtract the sucrose from the composition of beet molasses given in the previous table, we shall form a fair idea of the composition of *schlempe*. From 1000 kg. of beet molasses are obtained about 350 kg. of concentrated *schlempe*, containing about 30 percent. of mineral matter, mostly potash salts, some 20 percent. or more of nitrogenous substances, and a remainder of acids, gums, caramelization products, and other organic residues.

Molasses *schlempe* contains 12 to 15 percent. of potassium and 4 percent. or more of nitrogen, and its conversion into derivatives of these elements constitutes at present the chief method of utilization. The *schlempe* is first heated in retorts, by which means it is decomposed into a mixture of volatile products consisting of carbon dioxide, carbon monoxide, hydrogen, nitrogen, methane, ammonia, methyl amine, methyl alcohol, water, and other substances. The volatile decomposition products escape from the retorts at a tempera-

ture of about 400° C. and are led through a system of tubes heated to a temperature of about 1000° C. The effect of this heating is to convert the volatile nitrogenous compounds into ammonium cyanide, the gas after cyanization containing about 7 percent. NH_3 and 7 percent. HCN. After leaving the hot tubes, the gases, which are always kept under reduced pressure, are cooled, freed from tar, and then washed over sulphuric acid to break up the ammonium cyanide, the ammonium sulphate, which is formed, being recovered. The hydrocyanic acid is then absorbed in water and the residue of combustible gases is led back to the furnaces for heating the retorts. The hydrocyanic acid is then distilled, and absorbed in sodium hydroxide; the solution of the latter, after evaporating and crystallizing, yields solid sodium cyanide.

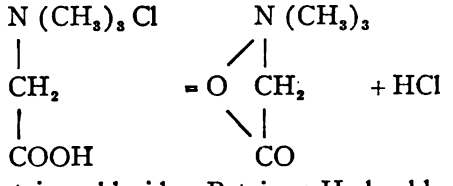
By the above method about three-fourths of the nitrogen in molasses *schlempe* is recovered as ammonium sulphate and sodium cyanide, the remaining one-fourth escaping as gaseous nitrogen. A small amount of pyridine is also obtained by this process, in connection with the ammonia. The residue of mineral matter in the retorts, after distilling the *schlempe,* is worked up into potash, of which some 15,000 tons are made annually in Germany from this source.

Two factories in Germany produce annually, by the process of distillation described, about 5,000 tons of ammonium sulphate and 5,000 tons of sodium cyanide, with a commercial value of about $1,750,000. The sodium cyanide thus manufactured is nearly all exported to the Transvaal, where it is used for extracting gold by the well known cyanide process.

Chemists in Germany are making further efforts towards improving the utilization of molasses *schlempe.* By the present methods of distillation, about one-fourth of the nitrogen is lost, and this is wasteful from the standpoint of highest economy. It has been felt by some chemists that efforts should be made towards removing some of the valuable organic constitutents of the *schlempe* before making the distillation. Among the more important of the nitrogenous organic substances, we may mention 10 to 12 percent. of betaine, 5 to 7 percent. of glutaminic acid, 1 to 2 percent. of leucine and isoleucine, and various other amino acids, neucleine bases, etc. The separation

of these compounds from the *schlempe* does not seem to be a difficult one. Search is being made for uses to which these substances may be put, and with the discovery of such uses we may look for greater refinements in the processes of utilization.

As an example of the specific uses to which the nitrogenous components of beet molasses may be put, we may mention that betaine is now prepared in Germany from molasses *schlempe* by extracting with alcohol and is marketed as crystalline betaine chloride under the pharmaceutical name of "acidol." Betaine chloride, when dissolved in water, is decomposed into betaine and free hydrochloric acid, according to the formula



Betaine chloride = Betaine + Hydrochloric acid

This property of betaine chloride offers a convenient means of giving hydrochloric acid medicinally in the form of a powder or pills; tablets of betaine chloride and pepsin under the name of "acidol-pepsin," are now prescribed for indigestion.

In the early days of sugar manufacture, the molasses and other by-products were regarded for the most part as useless encumbrances, and were disposed of by dumping into the ditch or the nearest stream; and these conditions still exist in very primitive countries. It is surely a great step from such a wasteful procedure to the methods of utilization practiced at present in the leading sugar producing countries.

STOPING DRILLS AT SUDBURY, ONTARIO.

BY ALBERT E. HALL.*

In late years the stoping drill of the hammer type has been steadily improved, until now no mine manager can afford to overlook the possibility of using it as a means of reducing his working costs.

A stoper is cheaper to operate, since it can be handled by one man instead of two, as required on a large machine. In some cases, a helper is assigned to two or three stopers, but as a rule this is not advisable. In addition, the use of stopers permits a larger proportion of the total time to be spent in actual drilling. With a big drill, much time is consumed in setting up after a blast or after moving to a new working place; with a stoper, on the other hand, the preparations for drilling are simple. As a rule, a stoper can be rigged up and set to work 30 to 40 minutes earlier than a big drill. One disadvantage of the stoper, when used for shrinkage stoping, is its tendency to create a large amount of shattered and partly loosened rock on the roof and walls of the working place. The men must first scale off this loose ground, which takes from 30 minutes to an hour. With a sufficient number of working places, however, this scaling can be done by a special gang of scalers, while the machine men are drilling in a previously scaled place.

As a result of the extra time applicable to drilling, and also of the more rapid drilling, stopers make an average of 30 to 40 linear feet of hole per shift, while a large drill will make 20 to 30 ft. As a rule, stopers work on a bench in the back. When necessary, a bench is created by taking out a diamond cut, and is then followed across the stope. The holes are made about 6 ft. deep. The amount of powder used (40 percent. dynamite) as computed from several groups of holes, averages 0.63 lb. per cubic yard of ore. The amount of air consumed by a stoper is estimated to be about two-thirds of that used by the largest drills.

Some workmen object to the stopers on the ground that stoppages for small repairs are too frequent. It is true that the dust, which is a disadvantage in itself, from the runner's standpoint, sometimes

* Creighton Mine, Ontario. E. M., Columbia, 1911.

clogs the valve and prevents the extension leg or standard from working properly, but only a few minutes are needed to clean out the valve, and if a screen or a bit of waste be put into the hose, this trouble is almost eliminated. Water sprays can also be used. On the basis of total repair bills, the stopers do not compare unfavorably with the larger machines.

In many places it is impracticable to use a stoper, and a big drill becomes necessary; for example, in hard rock, where the light drill makes little or no headway; but in shrinkage stoping the smaller machine does excellent work. The stoper has one advantage which is probably realized fully only by the men working underground: this relates to the matter of block-holing. Where the muck is being drawn off through chutes, the size must be fairly small so as not to block the chute and so hinder tramming and hoisting. With small stoping drills, the ground is generally broken small enough to pass readily through chutes, and very little block-holing is required. With large machines, on the other hand, considerable block-holing is necessary.

THE RELATION OF PYRRHOTITE TO CHALCOPYRITE AND OTHER SULPHIDES.*

BY ARTHUR P. THOMPSON.

The presence of copper ores in the metamorphic rocks of the States along the Atlantic seaboard has been known since early in the last century. The deposits have been frequently described, and by one author and another have been placed under different types. Thus, they have been regarded as beds, later in age than the foot-wall and older than the hanging; they have been considered segregated veins; and finally, they have been regarded as fissure veins, pinched into lenses during metamorphism. Most commonly the country rock of the mining regions is a schist. When this is the case the origin of the ore bodies is involved in some obscurity and they are usually classified with respect to their physical characteristics and mineralogy.

Among early writers on these deposits A. F. Wendt[1] gave an interesting account. J. D. Whitney in "The Metallic Wealth of the United States," reviewed the sulphide deposits in the East and later especially described the deposits of Ducktown, Tenn.[2] The excellent paper by Carl Henrich,[3] together with later contributions by J. F. Kemp,[4] W. H. Weed[5] and W. H. Emmons,[6] have made the observations on Ducktown much more complete than upon any other eastern deposit. H. S. Wheeler[7] described the Vermont

* A Master of Arts Thesis, Columbia University, 1912. The microscopic work was done in the metallographic laboratory of the School of Mines.

[1] "The Pyrite Deposits of the Alleghanies." SCHOOL OF MINES QUARTERLY, Vol. 7, 1886.

[2] J. D. Whitney. "Remarks on the Changes that take Place in the Structure and Composition of Mineral Veins." *Amer. Journ. Sci.*, ii, XX, 53.

[3] "The Ducktown Deposits and the Treatment of the Ducktown Copper Ores." *Trans.* A. I. M. E., XXV, 1895, p. 173.

[4] "Order of Formation of Minerals in Ducktown Veins." *Trans.* A. I. M. E., 1899. "Deposits of Copper Ores at Ducktown." *Trans.* A. I. M. E., XXXI, p. 244.

[5] "Types of Copper Deposits in the Southern United States." *Trans.* A. I. M. E., Vol. XXX, 1900, p. 449. "Copper Deposits of the Appalachian States." *Bull.* 455, U. S. G. S.

[6] "Metamorphosed Ore Deposits." *Econ. Geol.*, 1909, Vol. 4, p. 775.

[7] "Copper Deposits of Vermont." SCHOOL OF MINES QUARTERLY, IV, p. 219. "The Pyrohotite of the Ely Mines." *Eng. and Min. Journ.*, April 10, 1886, p. 263.

copper deposits, particularly the Ely mine. W. H. Emmons[8] and W. H. Weed[9] contributed results of later observations and studies of the deposits in the Appalachian States.

The observations noted below are the result of the study of specimens from orebodies from the following localities; in most cases the associated sulphide was pyrrhotite: Ducktown, Tenn., Vershire, Vt., Eustis, Que., the Union and Clegg mines, N. C., and Gordonsville, Va. A comparative examination has also been made of ore from the "Big Bonanza" mine, La Touche Island, Alaska. The specimens were furnished by Prof. James F. Kemp. Polished sections of the ore were prepared and studied by the microscope with reflected light, in the manner described by Dr. William Campbell.[10] The object of the study was to determine the relation of pyrrhotite to chalcopyrite, and the order of introduction and crystallization of these and any other sulphides present. No attempt has been made to distinguish different minerals of the gangue; they will be referred to hereafter simply as gangue.

The Deposits of Ducktown, Tenn.

The orebodies are lenticular in shape. As a rule they are parallel to the schistose country rock, but in some instances they cut the schistosity. Several lime silicates, of which garnet and zoisite are chief, have resulted from a probably calcareous original. There has been much compression and crushing where the ore is now found. Later, mineral-bearing solutions entered, probably replacing the finely crushed country rock and the silicates. In the Burra Burra the solutions deposited pyrite, and later pyrrhotite and chalcopyrite. Elsewhere pyrrhotite and chalcopyrite were introduced, the latter probably later and after an intermediate movement of the walls. Zinc blende occurs in minor amount at the Mary mine and, with galena, is probably later than pyrrhotite and chalcopyrite.

In the present investigation, specimens were examined from the Polk Co. and the Mary mines. The order of origin of the sulphides proved to be: (1) Blende; (2) pyrrhotite; (3) chalcopyrite. Pyrite was not observed in the specimens and galena occurred in such small amount that its relationship was obscure.

[8] "Metamorphosed Ore Deposits." *Econ. Geol.*, 1909, Vol. 4, p. 755.
[9] "Copper Deposits of the Appalachian States." *Bull.* 455, U. S. G. S.
[10] *Econ. Geol.*, Vol. I, p. 751.

The specimen from the Polk Co. mine consisted of crystalline and irregular masses of shattered gangue, the interstices being filled with the metallic sulphides. There had been an evident replacement of the gangue by the sulphides. Zinc blende was the chief sulphide to be deposited while pyrrhotite and chalcopyrite were found traversing the blende in numerous veinlets, as illustrated by Plate I, Fig. 1.

A characteristic feature of the blende is the occurrence of many fine, straight, and parallel streaks of pyrrhotite and chalcopyrite through it, and the parallel arrangement of many small included dots of the same minerals. It is evident that the last two sulphides have penetrated the blende along strain and cleavage cracks, and when the polished face has cut the minute veinlets parallel to their elongation, fine straight lines of the two sulphides are seen; when perpendicular to the veinlets, the section exposes parallel arrangements of dots of the two minerals. Viewed under the microscope with reflected light, the different minerals are characterized by colors which make them much more readily distinguishable than is possible in the photograph. Blende, when well polished, gives a smooth, blue surface. Chalcopyrite will also polish smooth, and reflects a bright, brass-yellow light. Pyrrhotite, generally more pitted on account of its brittleness, has a distinctive light bronze color.

Plate I, Fig. 2, shows pyrrhotite cut and corroded by a veinlet of chalcopyrite. Subsequent to the deposition of most of the pyrrhotite, a fracturing of the minerals occurred, which permitted the infiltration of solutions, bearing chalcopyrite. Chalcopyrite further favors the contact of pyrrhotite and blende, and is especially prominent around the edges of blende and gangue. The contacts of these minerals, parted during fracture, afforded the most convenient channels for the circulation of the solutions. From the intimate association of pyrrhotite and chalcopyrite in places, there appears to have been an overlapping of the periods of their deposition. Thus, after the crushing of the blende and pyrrhotite, a minor amount of pyrrhotite was deposited along with the chalcopyrite.

The specimen from the Mary mine contained minor amounts of galena and zinc blende. Galena occurred in such small quantity that its relations to the other sulphides could not be determined.

Blende, however, was found in isolated patches in chalcopyrite, showing irregular boundaries, due to the attack of the later solutions. The characteristic parallel dots of chalcopyrite are also observable. Pyrrhotite was found in similar relationship to chalcopyrite as in the Polk Co. specimens.

Summary.— (*a*) In all of the specimens examined, crushed silicates have been attacked and replaced. There is further a definite order of succession for the sulphides: (1) Blende; (2) pyrrhotite; (3) chalcopyrite.

(*b*) The blende and pyrrhotite have been strained and fractured and permeated by a minor amount of pyrrhotite and much chalcopyrite.

(*c*) The minerals in turn seem to have replaced each other. In the case of pyrrhotite and chalcopyrite, at least, there has been an overlapping in the periods of deposition.

Deposits of the Ely Mine, Vershire, Vt.

The country rock at Vershire is biotite schist, sharply folded, and cut by granite. The ore deposit has been described by W. H. Weed.[11] It is composed of two lenticular masses conformable to the foliation of the enclosing schist. The orebodies average 100 ft. along a N.-S. strike, 10 ft. in thickness, and 100 to 300 ft. along the dip of 24°. The ore minerals are pyrrhotite, chalcopyrite, some pyrite, and zinc blende. The gangue is quartz, actinolite and garnet. Biotite is very common in the ore, frequently in groups of elongated shreds.

The polished surface of the first specimen showed chalcopyrite as the predominant mineral. Zinc blende, pyrrhotite and gangue complete the list of minerals. Before the arrival of mineral-bearing solutions, the silicates were subject to considerable crushing. Blende was deposited first, around the edges of the gangue and in minute cracks through it. Without further disturbance, pyrrhotite was precipitated, surrounding particles of gangue and bordering blende; in some instances it penetrated the blende. In some parts of the section, pyrrhotite was observed in good crystalline form. surrounded by chalcopyrite. A period of crushing ensued after the

[11] "Copper Deposits of the Appalachian States," *Bull.* 455, U. S. G. S.

PLATE I

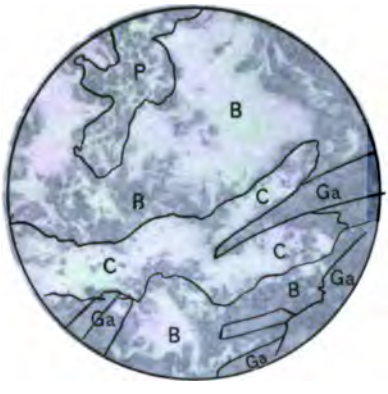


Fig.1

Fig.2

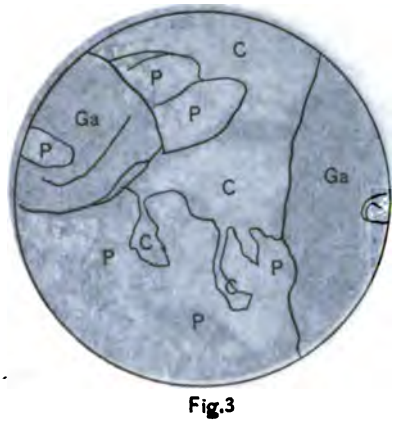


Fig.3

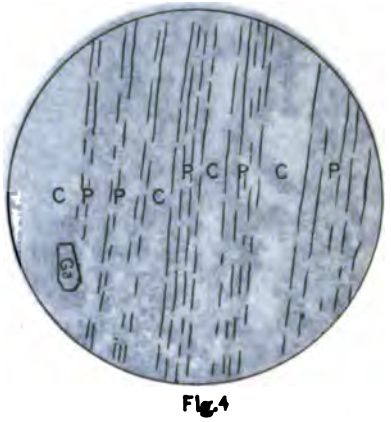


Fig.4

LEGEND

C=Chalcopyrite P=Pyrrhotite
B=Blende Ga=Gangue

...ce. However was found in isolated patches in c... ...g irregular boundaries, due to the attack of the later ... ...e parallel dots of chalcopyrite are also obs... ...te was found in similar relationship to chalcopyrite ...

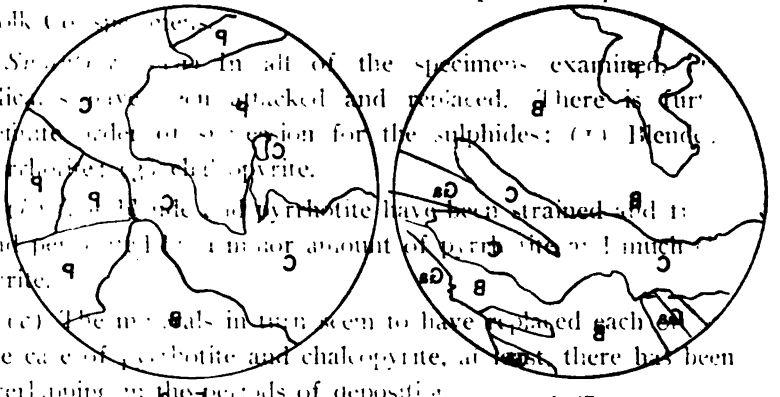


PLATE I

Fig. 1

Fig. 2

Structure.—In all of the specimens examined ... silicates were corroded and replaced. There is further ... ...te order of succession for the sulphides: (1) Blende, ...chalcopyrite.

... ...ens of pyrrhotite have been strained and ... ...and pyrite. ... ...a minor amount of pyrrhotite and much ... pyrite.

(c) The minerals in turn seem to have replaced each ... the case of pyrrhotite and chalcopyrite, at least, there has been overlapping in the periods of deposition.

PHOTOMICROGRAPHS OF ORE FROM THE LINE VEIN, VERSHIRE, VT.

The country rock is Versh... ...is biotite schist, sharply folded, ...cut by granite. The ore deposit has been described by W... ...Weed. It is composed of two particular masses conformable ... the foliation of the inclosing schist. The orebodies average 1... ...ft. along the strike, 10 to 40 ft. in thickness, and 100 to 300 ft. along the dip of the beds. The ore minerals are pyrrhotite, chalcopyrite, some pyrite and zinc blende. The gangue is quartz, actinolite and garnet. Biotite is very common in the ore, frequently in groups of elongated shreds.

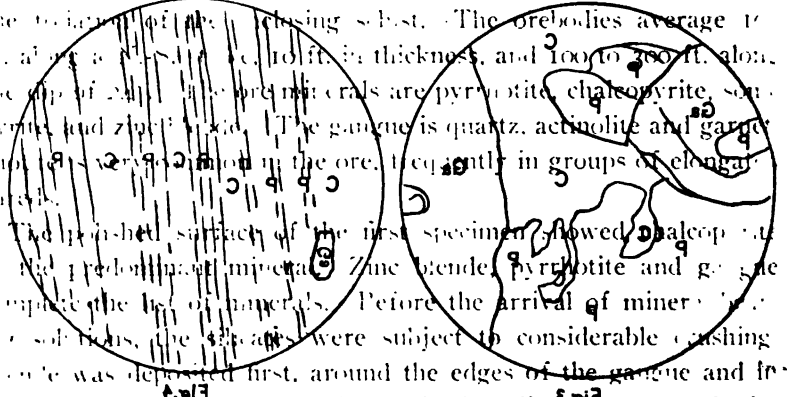
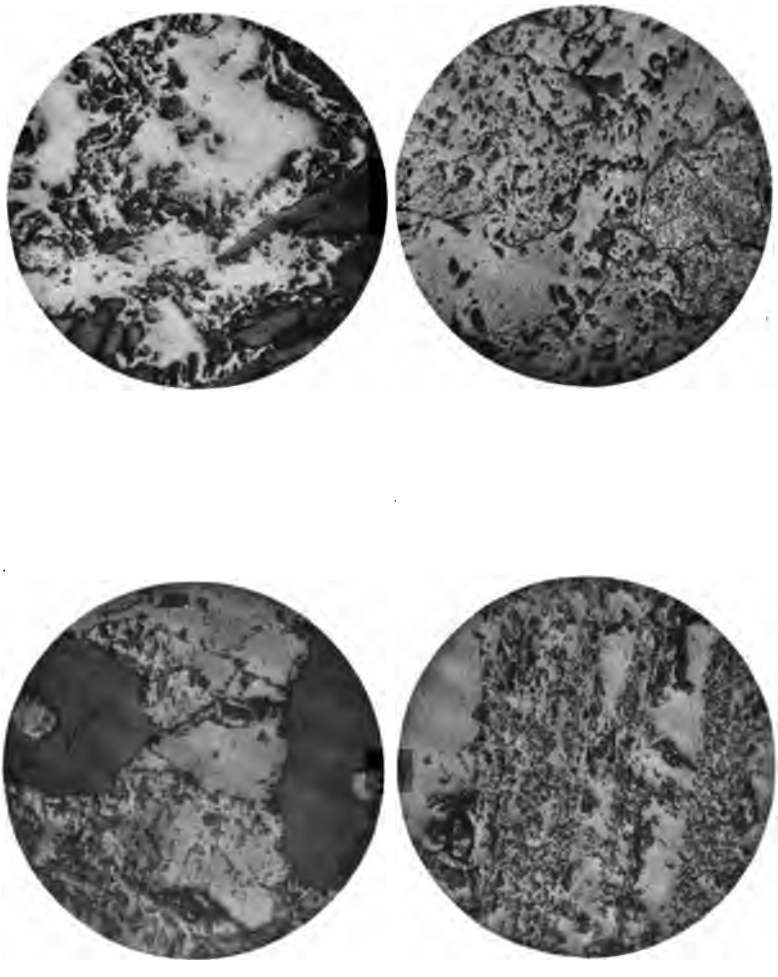


Fig. 3

Fig. 4

The polished surface of the first specimen showed chalcopyrite as the predominant mineral, zinc blende, pyrrhotite and gangue completing the list of minerals. Before the arrival of mineral solutions, the rocks were subject to considerable crushing. Pyrite was deposited first, around the edges of the gangue and in irregular cracks through it. Without further disturbance, pyrrhotite was precipitated, surrounding particles of gangue and bordering on pyrite, in some instances it penetrated the blende. In some part of the section, pyrrhotite was observed in good crystalline form ... by chalcopyrite. A period of crushing ensued after this

... Deposits of the Appalachian States," *Bull.* 455, U. S. G. S.



deposition of pyrrhotite, and later came the infiltration of chalcopyrite, which is found penetrating the gangue, blende and pyrrhotite, filling cracks and replacing, the other minerals. Plate I, Fig. 3, shows chalcopyrite cutting through pyrrhotite and entering it in little veinlets. It is evident that more or less replacement of the gangue minerals by the solutions of the metallic sulphides occurred. Further, the solutions bearing pyrrhotite appear to have impregnated and replaced blende, while solutions bearing chalcopyrite later replaced and impregnated both shattered blende and pyrrhotite.

In a second specimen a very small amount of blende was found. Pyrrhotite and chalcopyrite were present in abundance, filling cracks and replacing the gangue minerals. Plate I, Fig. 4, shows narrow strips of pyrrhotite surrounded by chalcopyrite. The pyrrhotite replaced narrow strips of gangue or entered between them and was deposited. Subsequently, the solutions bearing chalcopyrite, by either filling the intervening space or replacing the gangue with the copper-iron sulphide, helped to preserve the structure of the original minerals. Following the deposition of pyrrhotite, a period of crushing ensued which afforded channels for the entrance of solutions precipitating chalcopyrite. Thus, very well developed cracks through pyrrhotite are found filled with chalcopyrite. Finally the orebody suffered a fracturing which admitted solutions depositing quartz in minute veinlets through the ore.

Summary.— (*a*) The gangue was subjected to a considerable crushing and later solutions of the metallic sulphides entered the crushed zone and precipitated the sulphides, replacing more or less of the silicates.

(*b*) Blende was the first sulphide to be laid down and was followed by pyrrhotite.

(*c*) Subsequent to the deposition of pyrrhotite a crushing occurred which permitted the precipitation of the last sulphide, chalcopyrite, through cracks in the earlier minerals. Later disturbances admitted solutions depositing quartz in small amounts through the ore.

The Eustis Mine, Capelton, Quebec.

The following information was obtained from a published de-

scription by J. E. Dresser [12] and a statement by Major Lekie.[13] The country rock is schistose but somewhat variable. A considerable proportion was probably originally a diabase and the greater part was amygdaloidal. The lode, which conforms to the schistosity of the rocks, is a lense-shaped mass varying from 6 to 40 ft. in thickness. The ore is highly pyritiferous, but contains copper and 1 to 3 oz. of silver.

Several specimens of the Eustis ore were examined and, although the larger part proved to be pyrite, a very interesting group of minerals was recognized. Pyrite is well crystallized. It has suffered fracture, and through the fractures the solutions of the later sulphides have circulated, filling the cracks and replacing the pyrite. After the crushing, gangue minerals were deposited to a small extent and blende was precipitated in many places with crystalline form. Plate II, Fig. 1, shows blende surrounding crystals of pyrite. Plate II, Fig. 2, shows blende bordering pyrite. Well defined crystal faces of blende surrounded by bornite may be seen. On account of its hardness, pyrite retains scratches after the remainder of the section is well polished. It also stands out in relief from the softer enclosing minerals. Tetrahedrite occurs surrounding crystal faces of blende and traversing cracks through the latter. Bornite in turn has eaten its way into tetrahedrite, showing that it has followed the latter in order of formation.

Plate II, Fig. 2, shows characteristic smooth polished faces of bornite surrounding the lighter and more pitted crystals of zinc blende. Through the bornite, veinlets of chalcopyrite may be distinguished. In Plate II, Fig. 1, chalcopyrite can, with difficulty, be seen cutting through the bornite. Viewing the polished surfaces through the microscope, and in reflected light, the two minerals are very readily distinguished by their color, chalcopyrite presenting a bright brass-yellow surface, bornite a pinkish-brown. There appeared to be bornite of two shades of brown, the lighter colored apparently later than the other. Similar differences have been observed in the bornite from Butte, Montana.

Galena is seen in Plate II, Fig. 1, surrounding crystalline pyrite

[12] *Journ.* Can. Min. Inst., Vol. 5, 1902, p. 81-86.
[13] *Ibid.*, Vol 7, 1904, p. 400.

PLATE II

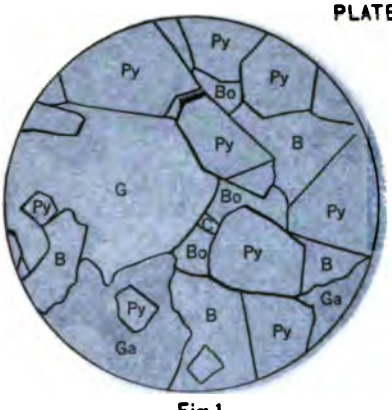


Fig.1

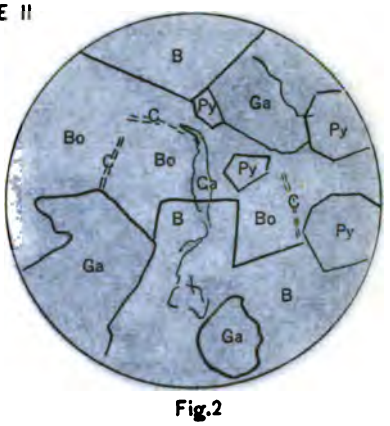


Fig.2

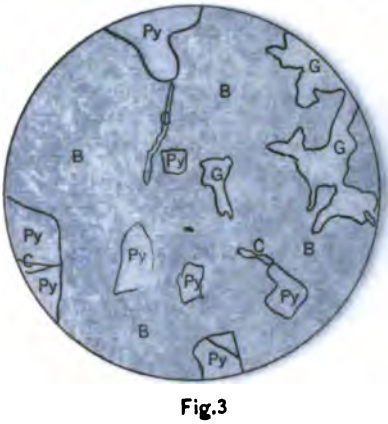


Fig.3

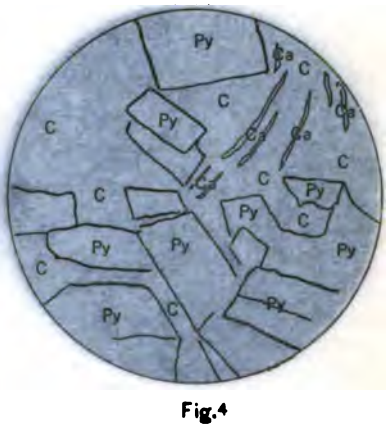


Fig.4

LEGEND

C = Chalcopyrite Ca = Chalcocite
Py = Pyrite G = Galena
B = Blende Ga = Gangue
Bo = Bornite

... by J. F. Kemp[1] and a statement by Major Leckie[2]. The country rock is ... stose but somewhat variable. A complete ... section was probably originally a diabase and the greater ... of it is ... The lode, which conforms to the schistosity of ... is a ... mass varying from 6 to 40 ft. in the ... ness. ... ly pyritiferous, but contains copper and ... 3 oz. ...

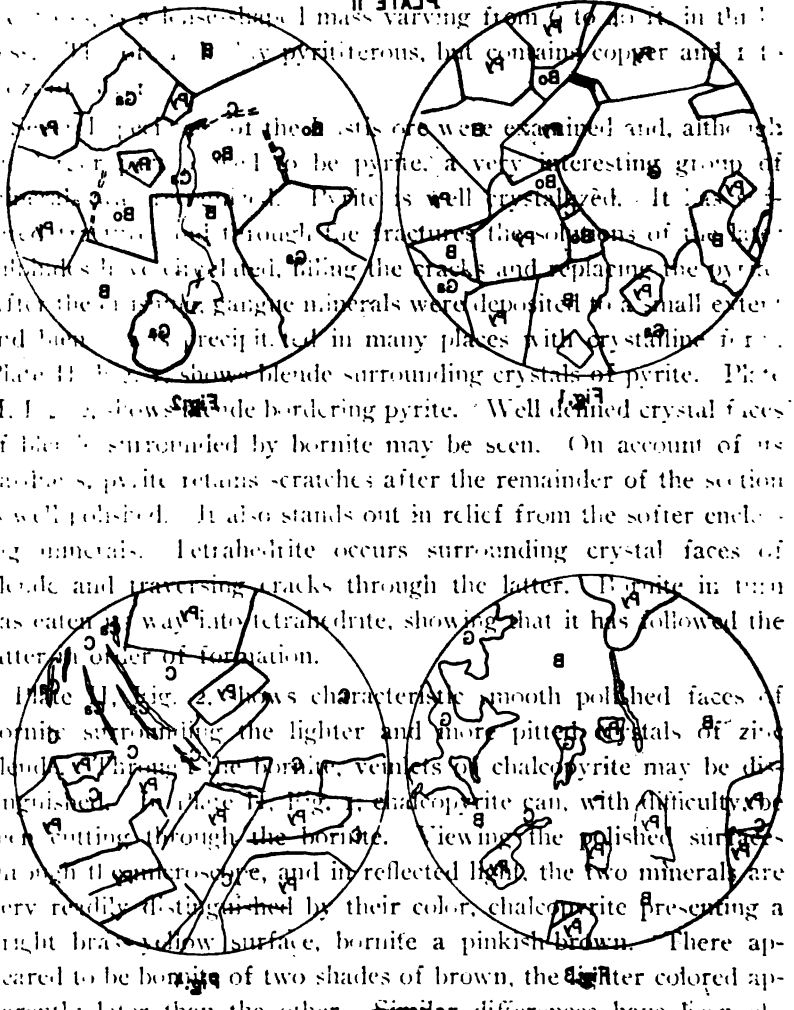
... of the ... sits ore were examined and, although ... r, ... to be pyrite, a very interesting group of ... Pyrite is well crystallized. It has ... through the fractures the solutions of the ... have ... filling the cracks and replacing the pyrite. ... the ... gangue minerals were deposited to a small extent ... and ... precipitated in many places with crystalline form. ... Plate II, ... shows blende surrounding crystals of pyrite. Plate II, ... shows blende bordering pyrite. Well defined crystal faces of ... surrounded by bornite may be seen. On account of its ... hardness, pyrite retains scratches after the remainder of the section is well polished. It also stands out in relief from the softer enclosing minerals. Tetrahedrite occurs surrounding crystal faces of blende and traversing cracks through the latter. Pyrite in turn has eaten its way into tetrahedrite, showing that it has followed the latter in order of formation.

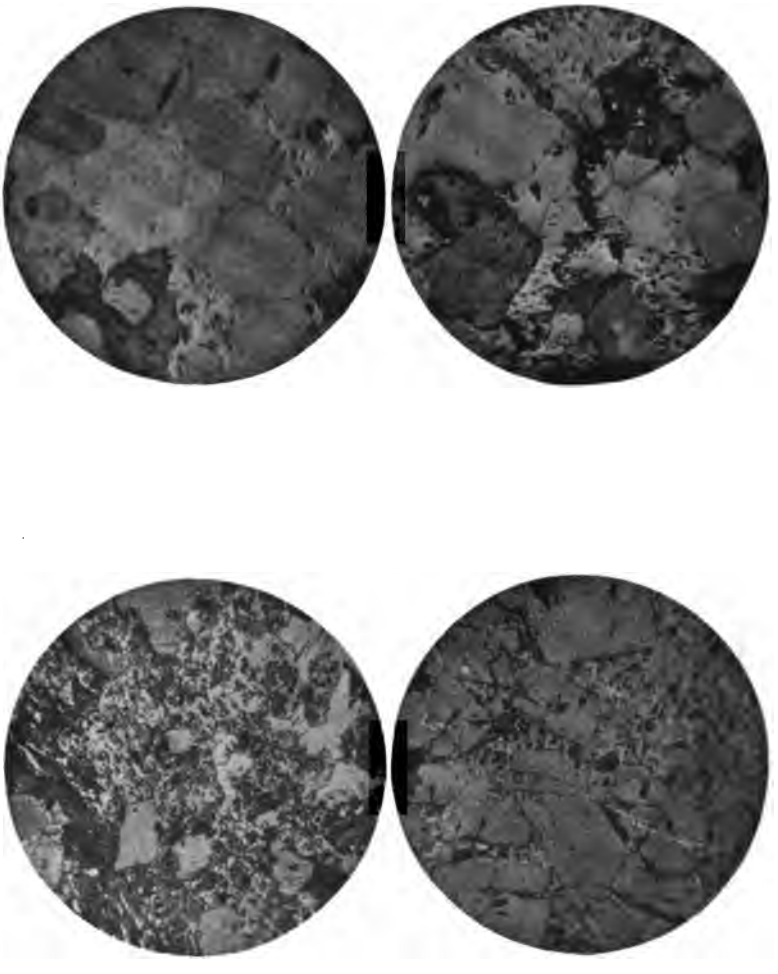
Plate II, fig. 2, shows characteristic smooth polished faces of bornite surrounding the lighter and more pitted crystals of zinc blende. Filling the bornite, veinlets of chalcopyrite may be distinguished. In Plate II, fig. 1, chalcopyrite can, with difficulty, be seen cutting through the bornite. Viewing the polished surfaces through the microscope, and in reflected light, the two minerals are very readily distinguished by their color, chalcopyrite presenting a bright brass-yellow surface, bornite a pinkish-brown. There appeared to be bornite of two shades of brown, the lighter colored apparently later than the other. Similar differences have been observed in the bornite from Butte, Montana.

Galena is seen in Plate II, fig. 1, surrounding crystalline pyrite

[1] ... Can. Min. Inst., Vol. 5, 1903, p. 81-86.
[2] ... Vol. 7, 1904, p. 400.

PLATE II





and blende, and in contact with bornite. It has come in after the bornite was deposited, as instanced by many crack fillings in the bornite and replacements of it. The galena is found at times in very intimate contact with the chalcopyrite. Although the evidence points to the fact that the chalcopyrite was the last mineral to form, there seems to have been an overlapping of the periods of deposition of the two sulphides. Galena shows a strong tendency to crystallize at all times. It presents a dazzling white surface by reflected light, and shows a very light color in the photograph.

Chalcopyrite fills cracks cutting through the galena, and seems to have especially impregnated the bornite with traversing veinlets and replacements.

In all of the specimens examined the same order of origin was traced: (1) Pyrite; (2) blende; (3) tetrahedrite; (4) bornite; (5) galena; (6) chalcopyrite. Thus it is seen that when pyrrhotite is lacking, the other sulphides bear about the same relation to each other. The silver reported in the ore is in too small a quantity to distinguish with the microscope. It is probable that it occurs in the galena or the tetrahedrite.

The North Carolina Deposits.

The Union Mine.— This deposit belongs to "The Gold Hill Type" as classified by W. H. Weed.[14] From his description the country rock appears to be an argillacious metamorphic schist. Fissure veins of auriferous quartz occur parallel to the foliation of the schist. The ores show no banding but exhibit a brecciated structure, the schist breccia being replaced by quartz or the ferro-magnesian minerals by ore. There are no definite walls to the fissure. After the crushing of the silicified schist and pyrite, chalcopyrite, together with a little galena, blende and new quartz, were deposited.

Study of specimens from the Union mine corroborates Mr. Weed's conclusions. Crystalline pyrite, older than any other sulphide present, has been subject to crushing. Plate II, Fig. 4, shows the characteristic structure of pyrite surrounded by chalcopyrite. Following this movement, gangue was precipitated in the crushed mass, and later zinc blende came in. The blende is shown in Plate

[14] "Types of Copper Deposits in Southern United States." *Trans.* A. I. M. E., Vol. 30, 1900, p. 470.

II, Fig. 3, where it has surrounded and replaced portions of pyrite crystals. Galena and chalcopyrite are seen ramifying through the blende. The blende presents a rough, pitted surface in the photo-micrograph and is with difficulty distinguished from chalcopyrite. Under the microscope, with reflected light, the polished surfaces of the two minerals afford colors that readily distinguish them.

Thus, it is seen that blende followed the pyrite; chalcopyrite and galena were then deposited in the order named, with perhaps an overlapping of periods suggested by their intimate associations in places. Finally, the chalcopyrite is found traversed by minute stringers of chalcocite, as shown in Plate II, Fig. 4. These tiny veinlets of chalcocite represent the alteration and secondary enrichment of the ore.

The Clegg Mine.— The greater part of this ore proved to be chalcopyrite. Within the chalcopyrite, well crystallized but crushed gangue was found, as shown in Plate III, Fig. 1. Blende occurs in small amount, much eroded and penetrated by extremely fine specks of chalcopyrite.

The most notable feature of this ore is its decomposition. The chalcopyrite has been subjected to strains which have produced much minute fracturing. In these fractures, and others that are largely the result of decomposition, the secondary products are found. The tendency of the cracks has been to form radially, with particles of gangue as centers. Alteration is confined chiefly to the chalcopyrite. On account of the very minute size of the cracks, not much definite data could be gathered concerning their contents. By etching with dilute HNO_3 the characteristic roughness of chalcocite was obtained. Bornite also appears frequently. Both of these sulphides are present as very fine films on the walls of the cracks. Covellite was distinguished in isolated grains. Plate III, Fig. 1, shows hardly distinguishable cracks filled with secondary sulphides, ramifying through chalcopyrite.

These specimens from North Carolina point to the same order of origin of the sulphides as found in the preceding cases. That is, (1) pyrite; (2) blende; (3) chalcopyrite. Galena seems to be variable in its position.

THE DEPOSITS NEAR GORDONSVILLE, VA.

Gordonsville lies on the eastern slope of the Southwest Mountain range. The orebodies of the region have been described by W. H. Weed.[15]

Examination of the ore showed pyrite, blende, pyrrhotite, chalcopyrite and galena, in the succession named. Pyrite, as in other cases, has been subjected to crushing. Solutions bearing gangue then entered and deposited their minerals between the crushed fragments of pyrite. Next, blende was introduced, in many cases in contact with the gangue and on the crystal faces of the minerals. The blende also fills scattered zones of the pyrite and replaces it in part.

Plate III, Fig. 2, shows crystalline and crushed pyrite with its characteristic scratched surface. Surrounding the pyrite are gangue, blende, pyrrhotite, chalcopyrite and galena. Pyrrhotite occurs in irregular patches traversing the pyrite, blende, and gangue. Chalcopyrite followed, entering the pyrite and attacking its edges. It occurs coursing through the gangue and the blende, as well as the pyrrhotite. The relation of galena to the other sulphides is obscure, since it is present in such small quantity. It has come in, however, later than the quartz. Chalcocite, the result of secondary enrichment, occurs as fine films in minute cracks and along lines of decomposition in the pyrite, pyrrhotite, and chalcopyrite.

Thus, in this locality the same relationship of the sulphides is found, viz.: (1) Pyrite, (2) blende, (3) pyrrhotite, (4) chalcopyrite.

"BIG BONANZA" DEPOSITS, LA TOUCHE ISLAND, ALASKA.

The "Big Bonanza" copper mine has been described by F. C. Lincoln.[16] The specimens examined support Lincoln's conclusions with respect to the occurrence of the ore. It is the result of replacement, impregnation, and filling of cavities in brecciated masses of slate or graywacke.

Study of the different types of occurrence of the ore has led to conclusions regarding the succession of the minerals somewhat different from those reached by Mr. Lincoln. Pyrite, in the polished

[15] "Copper Deposits of the Appalachian States," *Bull.* 455, U. S. G. S.

[16] *Econ. Geol.* Vol. IV., No. 3, p. 201.

sections, is the oldest of all the sulphides. It is found well crystallized, being bounded and traversed by cracks filled with all the other minerals. The main part of the gangue was next to come in, after a fracturing of the pyrite. The gangue shows very rough and irregular edges, due to the solvent action of later mineral-bearing solutions. This is illustrated by Plate III, Fig. 4.

Blende is found along the edges of the gangue and in isolated patches surrounded by pyrrhotite and chalcopyrite. Plate III, Fig. 4, shows an instance of the occurrence of blende. Cracks through the sphalerite are filled with pyrrhotite. In Plate III, Fig. 3, crushed crystals of pyrite are bordered by blende, pyrrhotite having come in later and surrounded both. Pyrrhotite is also found along the eroded edges of gangue, as in Plate III, Fig. 4, and in seams and irregular bodies in masses of chalcopyrite.

It appears that the deposition of pyrrhotite began before the entrance of chalcopyrite. Evidently the faces of the gangue minerals were most favorable to the precipitation of pyrrhotite, and here it is found along the contact of gangue and chalcopyrite. In places, the chalcopyrite is found penetrating into the pyrrhotite, which in turn protrudes away from the gangue into the chalcopyrite. Irregular and roughly parallel bodies and narrow strips of rounded pyrrhotite are found in larger areas of chalcopyrite. This occurrence led to the conclusions that the pyrrhotite solutions entered the country rock and gangue first, along roughly parallel lines of strain and fracture, and then replaced the material more susceptible to solution. Later, solutions carrying chalcopyrite replaced the country rock, or gangue surrounded the pyrrhotite, and left it in isolated patches.

It is quite probable that the deposition of pyrrhotite had not been concluded before chalcopyrite began precipitating. Indeed, from many of the occurrences of the two minerals, there seems to be no other possible conclusion except that there was an overlapping of the periods of deposition of the two minerals, with pyrrhotite definitely first.

The order of origin observed in these specimens was thus: (1) Pyrite, (2) gangue, (3) blende, (4) pyrrhotite, (5) chalcopyrite.

PLATE III

Fig.1

Fig.2

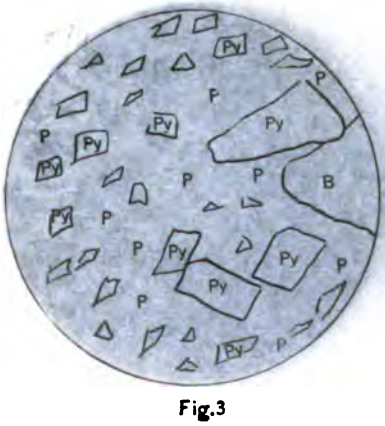


Fig.3

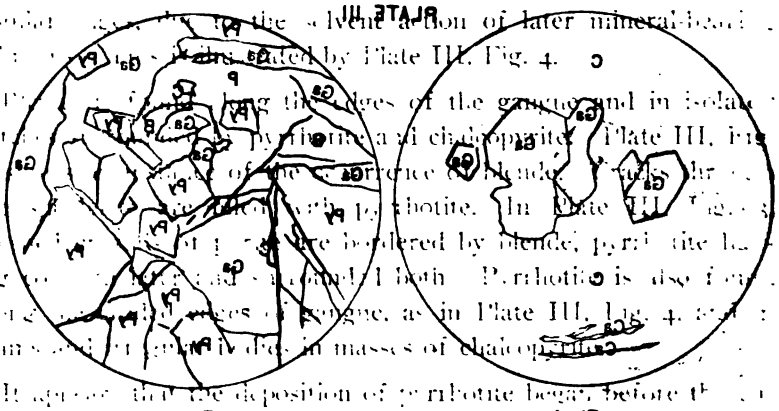
Fig.4

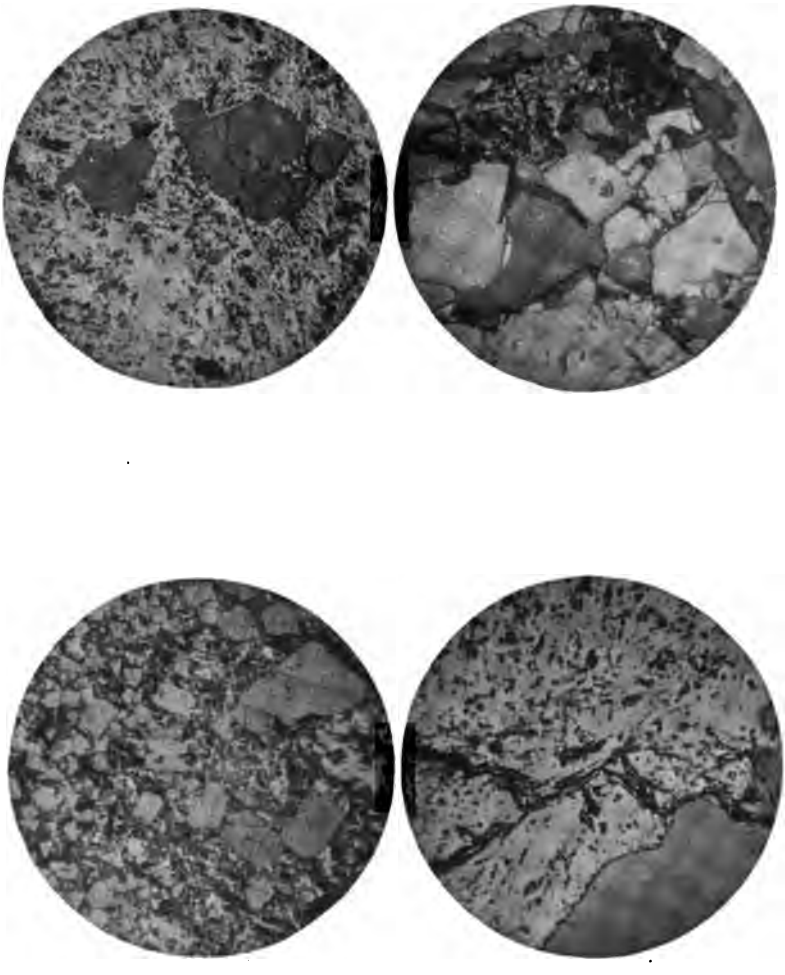
LEGEND

C = Chalcopyrite	P = Pyrrhotite
Ca = Chalcocite	B = Blende
Py = Pyrite	Ga = Gangue
G = Galena	

be oldest of all the sulphides. It is found well crystallized and traversed by cracks filled with all the other minerals. The main part of the gangue was next to come in, after the deposition of pyrrhotite. The gangue shows very rough and irregular boundaries, due to the solvent action of later mineral-bearing solutions, as illustrated by Plate III, Fig. 4.

PLATE III


Ga
Py
P
Ga
Py
Py
Ga
Py
Ga
Ga
Py
Ga
Py
Py
Py



Mr. Lincoln's order was: (1) Blende; (2) chalcopyrite, pyrrhotite and pyrite; (3) ankerite; (4) quartz.

Conclusions.

As a result of the metallographic examination of these specimens from widely separate mining regions, interesting conclusions may be drawn:

I. The order of origin of the metallic sulphides has been strikingly similar in all of the ores. That order is: (1) Pyrite; (2) blende; (3) pyrrhotite; (4) chalcopyrite.

II. The relation of pyrrhotite and chalcopyrite in some instances is very close, pyrrhotite, however, being distinctly the first to form.

III. Galena is somewhat variable in its occurrence, but is usually formed as one of the later sulphides.

IV. The presence of silver and gold, unless in comparatively large amounts, may not be observed in a polished section.

V. The periods of deposition of the sulphides are not necessarily distinct and separate phases of the formation of the ore. The association of two or more sulphides may be so close that their relative ages are impossible to ascertain. Overlapping of periods may occur, giving no definite clues as to the ages of the sulphides.

VI. Solutions of the later sulphides have, in turn, generally replaced and impregnated the earliest formed sulphides as well as the gangue. Chalcopyrite has been particularly active in this respect. To a less degree galena does the same. Quartz gangue has been repeatedly corroded and replaced by later solutions bearing the metallic sulphides.

ABSTRACTS—ANALYTICAL CHEMISTRY.

BY E. WALLER.

APPARATUS — REAGENTS — MANIPULATION.

Standardizing Permanganate, etc.— Florentin. (*Bull. Soc. Chim.*, XIII, 362) The use of $FeSO_4,H_2O$ is proposed. Unlike the $7H_2O$ form, it does not oxidize or alter on keeping, and can be heated to 120° C. without losing H_2O. In cold H_2O it dissolves but slowly, but on acidfying and warming dissolves readily. Prepared by dehydration of $FeSO_4$, $7H_2O$ by heating, some oxidation occurs. The better method is by crystallization from 50 percent. H_2SO_4. After purifying the $7H_2O$ salt by repeated recrystallizations, treat about 400 gm. of that salt in a flask with 200 c.c. of 50 percent. H_2SO_4. Heat gently on the water bath, agitating the flask frequently. The salt dissolves almost completely, when suddenly, at a certain temperature, a white crystalline powder forms. Heat for a short time, filter on a Buchner filter, and wash with 90 percent. alcohol or dry acetone, then with dry ether, and dry out over H_2SO_4. The yield should be about 40 gm. $FeSO_4,H_2O$.

Hypochlorites.— Williams. (*C. N.*, CVII, 109) A method has been proposed, involving the measurement of the N evolved by running a solution of the hypochlorite into a boiling solution of hydrazine sulfate acidified with H_2SO_4. A simpler method is proposed which consists in titrating the hypochlorite solution directly with hydrazine sulfate solution (3.2535 gm. per litre) using starch-iodide paper indicator, as with the ordinary As_2O_3 method. The solution must be kept on the alkaline side, which it may be necessary to insure by adding a little $NaHCO_3$. The reaction is apparently: $N_2H_4 + 2MOCl = N_2 + 2H_2O + 2MCl$. 1 c.c. of the above solution = 0.003546Cl.

Purification of Sulfuric Acid.— Bressanin. (*Gazz. Chim. Ital.*, XLII, 456) Bring the acid to strength of 50° Be. add 10 cc. per litre of 30 percent. solution of HI and allow to stand 12 hours. HNO_3 and NO_2 are converted to NO. As, Sn, Cu, Cd, Se are completely precipitated. Hg and Bi are not eliminated. Filter through asbestos, and expel I and HI by heating in a Jenaflask.

Sodium Peroxide.— Herbig. (*Färber Ztg.*, xxiii, 193) Put 400 c.c. of 1:10 H_2SO_4 in a beaker of such capacity that the liquid is 10 to 12 cm. deep. Add clean ice until the temperature is brought down to 0° C. Then drop in, in horizontal position, a weighing tube containing 0.2 to 0.3 gm. of the sample. The acid should only gradually react with the Na_2O. If all is attacked at once the results are irregular. Finally titrate with standard $KMnO_4$. The ice should be tested in blank to determine whatever correction may be necessary. The iodide method may also be used: The sample in a weighing tube, as before, is placed in a 10 percent. solution of KI acidified with HCl, contained in a flask which is kept tightly stoppered for 45 min. The solution is

then largely diluted and titrated with $Na_2S_2O_3$. The KI solution must be strong for reaction with the Na_2O_2, but dilute for the titration. $Na_2S_2O_3$ solution must be added slowly.

ORES — METALLURGICAL (NON-FERROUS) PRODUCTS.

Copper in White Metal.— Ibbotson and Aitchison. (*C. N.*, CVII, 121) Jaunasch and Biedermann (*Ber.*, 1900, 631) have shown that Cu may be separated from Sn by running a solution of the mixed metals into hot solution of NaOH with hydrazine hydrochloride. Cu separates at first as Cu_2O, which eventually reduces to metal. Hydrazine sulfate, instead of the hydrochloride, gave an incomplete separation. The authors find that the method is applicable for the separation of Cu in solutions of white metal. The method consists in dissolving 0.5 gm. of the alloy in 10 to 15 c.c. aqua regia, and diluting with an equal bulk of H_2O. If $PbCl_2$ separates, filter off through a small filter, and wash with cold H_2O. Add about 1 gm. tartaric to the solution, and then NaOH until free acid is nearly neutralized. Heat to boiling, and run drop by drop into a boiling solution of 20 gm. NaOH with 2 to 3 gm. hydrazine hydrochloride in 250 to 300 c.c. H_2O, agitating vigorously. Digest about 15 min., and then filter through ashless paper pulp. Wash with hot H_2O. Dissolve from the filter by 1.2 HNO_3 diluted with equal bulk of H_2O; evaporate off free acid. On taking up with H_2O, any opalescence due to SnO_2 should be filtered off. Cu may be determined in the solution by I method.

Titanium.— Thornton (*Am. J. Sci.* XXXIV, 214) In the tartaric acid method for separation from Fe, which consists in adding tartaric and precipitating out Fe by $(NH_4)_2S$, the destruction of the tartaric by permanganate is objectionable on account of the presence of the Mn. Fuming HNO_3 was found to be more satisfactory. Use three times as much tartaric as the oxides to be held in solution, e.g., 1.0 gm. rutile would require 3 gm. tartaric. After separating the Fe, evaporate until the tartaric begins to char, then cover and heat to frothing, cool a little and add 5 c.c. fuming HNO_3. Heat cautiously at first, then more strongly, continuing until SO_3 fumes begin to come off, leaving a pale yellow solution. Cool, dilute, neutralize as closely with NH_4OH as is possible, without giving a permanent precipatate, add 1 c.c. strong NH_4HSO_3 solution, then 5 c.c. glacial acetic and 15 gm. $NH_4C_2H_3O_2$. Bring to 350 c.c. and boil for a few minutes. Wash with H_2O acidified with acetic at first, finally with pure H_2O.

Titanium, Colorimetric.— Lenher and Crawford (*Ch. News.*, CVII, 152) TiO_2 in solution in conc. H_2SO_4 affords marked colorations with many organic bases and compounds, but with very few is the intensity of color proportional to the TiO_2 present. In the case of thymol, the coloration (red) is proportional to the TiO_2. To obtain a stable colorless solution of thymol in conc. H_2SO_4, dissolve in a little glacial acetic containing 10 percent. of alcohol, and then add the H_2SO_4. If kept out of sunlight this solution will remain colorless. To determine TiO_2, fuse

with $KHSO_4$, dissolve the melt in conc. H_2SO_4, add enough of the thymol-H_2SO_4 solution to have present at least 0.006 gm. thymol to every 0.0001 gm. TiO_2, dilute with conc. H_2SO_4 to a convenient bulk, and compare with standards prepared in the same manner. The intensity of coloration is twenty-five times as great as with H_2O_2. Dilution with water produces no effects until the strength of the H_2SO_4 falls below 79.4 percent. Heating pales the color, which returns on cooling, unless it has been heated to 100°. Florides prevent, and WO_3 intensifies the coloration; other substances, as Sn, P_2O_5, HCl, etc., appear to have no effect.

Sulfur in Pyrites.— Allen and Bishop (8th Int. Cong. Appl. Chem., I, 33) The noticeable features are: Oxidizing by Br in CCl_4, which moderates the action. Precipitation by slow addition of $BaCl_2$ to a cold solution in which Fe has been reduced to *-ous* form. Process is: do not grind finer than 80 mesh. Take (factor weight) 1.3736 gm. in a 300-c.c. beaker, add 10 c.c. of mixture of 2 Br to 3 of CCl_4 by vol. After 15 min. add 15 c.c. HNO_3, let stand 15 min. more, then apply heat, until almost all Br has been expelled, when the cover can be removed, and evaporation continued to dryness. Add HCl and evaporate to dryness again. Heat for some time to render SiO_2 insoluble. Wet down with 4 c.c. conc. HCl, warm, then add 100 c.c. H_2O and boil. Cool a little and introduce 0.2 to 0.3 gm. Al powder to reduce Fe. Filter and wash. Dilute to 1600 c.c., and add 6 c.c. more HCl. Run in 125 c.c. $BaCl_2$ solution at the rate of about 5 c.c. per min. without stirring until after all has been added. Then let stand 2 hours. Filter through a Gooch, with rather thick asbestos mat. Wash 6 times with cold H_2O. Dry, ignite, and weigh. Ppt.x 10 = percent. S.

Manganese in Ores, Spiegel, etc.— Crook (*C. N.*, CVII, 157) The author's mode of applying the Volhard method is given. Dissolve 2 gm. in suitable acids, finally add 10 c.c. H_2SO_4 and evaporate to fumes. Dilute to 500 c.c., boil, and precipitate with ZnO emulsion in a litre flask. Filter and wash, and treat precipitate and insoluble residue with H_2SO_4 and evaporate to fumes. Reprecipitate with ZnO as before, and unite the solutions without filtering. Cool, make up to 1 litre, and pipette off amounts representing 0.25 or 0.5 gm. for titration with standard $KMnO_4$. This amount should be brought to 600 c.c. bulk in a flask, and the $KMnO_4$ must be added with constant and repeated swirling and boiling until the pink color persists for several hours. If overrun, a fresh lot must be pipetted off for titration. Suggestion is made that one lot may be treated in this way (adding 2 c.c. $KMnO_4$ at a time) to get an approximation, which will guide one on the titration more closely of a second portion.

Zinc Titration by Ferrocyanide, Effects of Lead.— Lenher and Meloche. (*C. N.*, CVII, 161) In presence of 1.5 to 6 percent. free HCl, Pb has no effect on the Zn titration. Per contra, the ferrocyanide titration of Pb can only be accurate, in acetic solution, in the absence of material amounts of HCl or chlorides.

Separation of Zinc and Nickel.— Cockburn, Gardiner and Black. (*Analyst,* XXXVIII, 443.) Examination of methods. Method of Lewis — just neutralizing with Na_2CO_3, adding 100 c.c. glacial acetic, and passing H_2S slowly, 2 bubbles per sec. for 1 hour — was found to be satisfactory unless the proportion of Ni was too great. 0.110 to 0.679 gm. Zn was thus separable from 0.1934 gm. Ni in solution of about 250 c.c. total volume. Waring's formic acid method — neutralizing as before, then adding 0.5 c.c. formic and then passing H_2S at 80° C.— is preferable, and gave similar results, satisfactory, except in the case of much Ni. Precipitation from solution slightly acid with HCl was unsatisfactory: also Zimmerman's KCy method. In estimating Ni in the filtrates, the persulfate method of Dede was tried — separating $Ni_2(OH)_6$. The precipitates invariably held occluded alkali. The dimethyl glyoxime method was very satisfactory. Concentration should not be greater than 0.07 gm. Ni in 250 c.c., on account of the bulk of precipitate.

Alkalies in Rocks.— Krishnayya. (*C. N.,* CVII, 100) Treat 1 gm. or more with H_2SO_4 and HF to remove SiO_2 in the usual manner. Boil the residue with dilute HCl, and if any portion fails to dissolve repeate the HF treatment until all will dissolve in dilute HCl. Evaporate an amount of the solution corresponding to 1 gm. of the original to dryness, and ignite to complete cessation of SO_3 fumes. Break up the cake, boil it with H_2O, and without filtering, add $BaCl_2$ to convert sulfates to chlorides. Add $Ba(OH)_2$ solution to remove bases other than alkalies, and continue in the ordinary conventional manner, weighing up mixed NaCl and KCl, followed by H_2PtCl_6 for the K, etc.

Volumetric for Tin.— Rawlins. (*C. N.,* CVII, 53) Examination of several methods.

(*a*) To obtain the $SnCl_2$ solutions for the purpose, 1 gm. lots of pure rolled Sn were placed in as many flasks, to which had been fitted funnel tubes and escape tubes, the escape tube of one flask delivering into the funnel tube of the next. In the first flask, besides the Sn, was put a 3 gm. lump of white marble. 50 c.c. conc. HCl were then added to each flask, and the action allowed to proceed until all Sn was dissolved, and the solutions had become cold. Warming was not necessary.

(*b*) Adding excess of standard $FeCl_3$ and titrating back with $TiCl_3$, using NH_4CNS as indicator, the flask being kept full of CO_2, afforded good results. Sb, except in minute traces, was prejudicial. Cu had no effect.

(*c*) Titration with $FeCl_3$ alone, using Cu_2I and starch as indicator, was found feasible, though the end point was not quite so sharp as might be expected.

(*d*) Titration with I and starch indicator also gave satisfactory results. It was found advisable partially to neutralize the large excess of strong acid, by adding some $NaCO_3$ before titration. Sb interferes as before, but if the amount is known (determined otherwise), a correction for the same can be applied.

Tin in Bronze.— Ibbotson and Aitchison. (*Ch. News,* CVII, 109) Success with this method depends chiefly on the regulation of the proportion of acids used in the solution which is reduced by Sb and titrated with $N/_{10}I$ solution. Weigh out an amount of the alloy which should contain approximately 0.1 gm. Sn. Dissolve in 10 to 15 c.c. HNO_3 (Gr. 1.4). Evaporate to a paste, then add 75 c.c. H_2O, and boil for a few minutes. Filter by decantation hot through a closely packed asbestos filter, keeping as much of the precipitate as possible in the original flask. Wash off all free HNO_3 and return filter and precipitate to the original flask, using as little water as possible. Add conc. H_2SO_4 in amount equal to the bulk of the H_2O used, boil for 3 min., then add 50 c.c. conc. HCl and boil 2 min. more, which should give a clear solution. Connect with a CO_2 generator, add 1 gm. pulverized Sb, boil for about a minute, then cool down quickly and when cold titrate rapidly with $N/_{20}I$ solution with starch indicator.

Copper — Sulfocyanate-Permanganate Method.— Demorest. (*J. Ind. Eng. Chem.,* V, 215) In the method of Guess, the CuCNS is treated on the filter with NaOH, the filtrate acidified with H_2SO_4 and then titrated with $KMnO_4$. Practically the oxidation in acid solution is never complete, and a correction must be applied. Oxidation in the alkaline solution is proposed. Take an amount of ore which should contain 0.05 to 0.3 gm. Cu., decompose with HCl, followed by HNO_3 and eventually by H_2SO_4, and evaporate to fumes. Cool, and add 50 c.c. H_2O containing 3 gm. tartaric. Heat to dissolve all soluble salts, add NH_4OH to deep blue, acidify by H_2SO_4 add 1 gm. Na_2SO_3 in 20 c.c. H_2O, and then add slowly, with vigorous stirring, 1 gm. KCNS in 20 c.c. H_2O. Heat for some minutes to coagulate the precipitate. Filter preferably through an asbestos Gooch. Wash well, then pour through it 30 c.c. of hot 10 percent. NaOH solution, and wash down. Warm, and run in slowly standard $KMnO_4$. Take out a drop from time to time, for spot test, with 1 drop HCl and 1 drop $FeCl_3$. When the red color becomes faint, acidify the Cu solution with H_2SO_4 and finish titrating in the acid solution. Fe standard $\times$ 0.1897 = Cu standard.

Separation of Glucinum from Aluminum.— Wunder and Wegener. (*Zts. Anal. Chem.,* LI, 470) Fuse the mixed oxides for 2 to 3 hours with Na_2CO_3, take up with H_2O and wash with Na_2CO_3 solution. Al_2O_3 is dissolved; BeO remains; Fe_2O_3, if present, remains with the BeO. It can be separated by fusing with $NaHSO_4$; on taking up with NaOH, BeO, dissolves.

MISCELLANEOUS.

Nitrates in Waters.— Lombard. (*Bull. Soc. Chim.,* XIII, 304) Dissolve, by heating, 1 gm. sulfanilic acid in 100 c.c. of saturated solution of NH_4Cl, and add 1.5 gm. phenol; then add 100 c.c. of approximately 2N/HCl. 1 c.c. of this reagent is added to 50 c.c. of the water tested, and after standing 15 min., 1 c.c. NH_4OH solution is added, or an amount sufficient to render the mixture decidedly alkaline. The tints obtained can be exactly matched by dilution of $K_2Cr_2O_7$ solutions, and

by this means a set of permanent standards can be made up for reference. If the reagent is only in occasional use, 100 c.c. of H_2O is added instead of the 2/N HCl, and 1 c.c. of N/HCl is added at the time of testing.

Prussian Blue in Weighted Silks, etc.— Williams and Draper. (*Thro. C. N.*, CVII, 52) The material is distilled with a 10 percent solution of H_2SO_4, to which 1 gm. CuCl and a few drops of conc. HCl have been added. The distillate carries off all the HCN which is caught in solution of KOH or NaOH. This is then titrated with $N/_{10}$ $AgNO_3$ of which 1 c.c.= 0.00955 anhydrous or 0.01355 hydrated Prussian blue.

BOOK REVIEWS.

Transmission Line Formulas. By H. B. DWIGHT. Cloth; 5×8 in.; 137 pp.; illus. D. Van Nostrand Co., New York. 1913. Price $2 net.

There is a growing tendency among engineers to use that type of book called the "pocket-book." Such a book aims to give in as brief a space as possible such working formulas and tables as are needed for obtaining quickly and with a fair degree of accuracy the solutions to definite problems. This style of book is to be differentiated from the engineering text-book, written with the idea of explaining to the student the derivation and significance of these formulas.

This small volume on transmission line formulas is of the pocket-book type. Many formulas and tables are given, and typical problems are worked out to show how the formulas are applied. For short lines, a simple set of relations between regulation, load, voltage, power factor, etc., are given, and for longer lines the author introduces into these relations a constant K, which makes the formulas applicable to any problem likely to arise in practice. At the beginning of each set of formulas the author gives the possible percentage by which the results obtained may differ from the accurate solution of the line. The values which this possible error may take are very small, and show that approximate relations, such as the formulas express, do solve ordinary problems with sufficient accuracy.

The accurate solution of transmission lines can be obtained only by the use of hyperbolic trigonometry. It is stated in the introduction that the formulas given in the book are easier to handle than hyperbolic functions, but in this the reviewer would differ from the author. The actual solution of some of the formulas given by the author requires a tremendous amount of calculation; whereas the use of the hyperbolic trigonometry requires but very little. The hyperbolic solution would give the accurate solution and the other formula would give an approximate solution.

The book is written, the author states, for engineers and engineering students, but the use of such a book in engineering schools, except as a check on other methods, would be of little value. The formulas are long and very involved, and even an expert could not give, by means of them, an explanation of the effects of the difficult constants of the line. For the practicing engineer who wants results and does not care to understand the significance of the steps by which he arrives at the results, the book will probably be of considerable service. For engineering schools the reviewer does not consider the book at all suitable.

An ingenious chart is loosely bound in the book and may be removed for mounting on stiff board; by means of it the proper size of wire to use for the transmission of a certain amount of power, with specified regulation, etc., may be at once obtained. The chart should be very useful to a man who has much of this kind of work to carry out.

J. H. M.

Chemical Theory and Calculations; An Elementary Text-book. By FORSYTH JAMES WILSON and ISIDOR M. HEILBRON. Cloth; 4½×7 in.; 138 pp.; illus. D. Van Nostrand Co., New York. 1912. Price $1 net.

The object of this little book is to present the elements of chemical theory as distinct from descriptive chemistry. Its chapter headings will serve to call attention to its somewhat ambitious claims: the metric system; density and specific gravity; thermometry; the gas laws; solubility of gases in liquids; the atomic theory; formulas and equations; calculation of percentage composition of a compound from its formula; calculation of empirical formula from percentage composition; equivalents or combining weights; atomic weights; valency; the periodic classification of the elements; the law of mass action; the determination of vapour densities; osmotic-pressure and molecular weight determinations; dissociation of gases; electrolytic dissociation; diffusion of gases; quantitative analysis; thermochemistry.

With only 138 pages at the disposal of the authors, the treatment of all the above topics must of necessity be superficial, but by the use of arithmetical problems they have succeeded in giving the student who works through the book a very good general idea of what theoretical chemistry is in its elements. The student in his second chemistry course will undoubtedly find the book both useful and valuable.

J. L. R. MORGAN.

Coal, its Composition, Analysis, Utilization and Valuation. By E. E. SOMERMEIER, Professor of Metallurgy, Ohio State University. Cloth; 6×9 in.; viii+175 pp.; illus. McGraw-Hill Book Company, New York, 1912. Price $2 net.

The author states that this book is written for three classes of readers: (1) the mechanical and power plant engineer, (2) the chemist and chemical engineer, (3) the business man and operator who, though not technically trained, has to do with the buying and selling of coal. Hence not all of the material presented is expected to appeal to any one reader. The book deals chiefly with the sampling and analysis of coal, the determining of calorific value, the relation of composition to heating value, the improvement of coal by washing, purchase of coal under specifications, flue gas analysis, and tables of analyses of American coals arranged alphabetically by states. Examples cited in the text are usually drawn from the author's experience with Ohio coals. A commendably full discussion of sampling is given, and it is pointed out that failure to secure a representative sample may result in errors ten times as large as the probable errors of analysis. The author advocates the grinding of the final sample to a fineness of 60 (or occasionally 80) mesh rather than to 100 mesh, because of the more rapid oxidation of the more finely pulverized sample.

The detailed discussion of the determination of heat of combustion by the bomb calorimeter, based on the author's extended experience is another very valuable feature. The short chapter on improvement of coal by washing is also authoritative and valuable.

The introductory explanations regarding the purchase of coal under specifications are good, but this subject is hardly so fully developed as might be expected in a special work of this character. However, the general principles are made so clear that the individual purchaser should be enabled to work out the specifications suitable to his own case.

In discussing the relation between ultimate composition and calorific power, the author appears to accept the view that the assignment of the oxygen of the dry fuel to hydrogen or to carbon for purposes of calculating heat value should depend upon the extent to which the oxygen is given off as water when the coal is heated out of contact with air. This, however, has been shown to be incorrect, since in many cases the oxygen must all be assigned to the carbon in order to obtain a correct calculated heat value.

The work concludes with tables showing the proximate and ultimate analyses and calorific powers of about 200 American coals, the data being taken from publications of the U. S. Geological Survey and Ohio Geological Survey. The authority for each of these analyses is indicated, but in most of the book the references to original literature are noticeably few.

The book as a whole is a timely and useful work, and should be read by all who are responsible for either the purchase or the testing of coal.

H. C. SHERMAN.

Building Stones and Clay-Products, A Handbook for Architects. By HEINRICH RIES, Ph.D. Cloth; 8vo, xii + 415 pages, 59 full page halftone plates and 20 figures. John Wiley & Sons, New York, 1912. Price $3.00 net.

The first chapters of this book deal with building stones. Chapter II, which treats of the properties of building stones, is well written and contains much valuable information. If architects would investigate the weathering properties of their materials more thoroughly, their buildings would last longer and look better.

The chapter on slate is to be commended for its information in regard to the discoloration of slates from the various quarries. The weathering of slate is almost as important to an architect as its strength and durability.

Chapter IX on the different kinds of building brick gives an excellent standard specification, which is sure to be appreciated by all who are engaged in specification writing. Very little information, however, is given about pressed bricks or facing bricks, and in view of the extensive use of these materials at the present time, more consideration is due them. The chapter would also have been improved by the insertion of photographs showing the different bonds or patterns for laying face brick and the effect obtained by using joints of various thicknesses and texture.

The chapters on architectural terra and terra cotta fireproofing, while excellent as far as they go, do not give enough information about these important materials. A standard form of specification, similar to the

one given for building bricks, would have been useful, also drawings illustrating the jointing of architectural terra cotta.

The final chapters are devoted to roofing tile, wall and floor tile, sewer pipe and sanitary ware.

While not an exhaustive treatise on the subjects of building stones and clay-products, this book gives many fundamentally important facts especially about the methods of manufacture, properties and durability of clay-products, which will guide architects to a wiser selection and more intelligent use of these materials. It is a book that should be in the library of every architect who is engaged in the active practice of his profession, especially in these days of fire proof construction.

C. P. W.

Mechanical Drawing. By OTHO M. GRAVES, Assistant Professor of Graphics, Lafayette College. Cloth; 6×9 in.; 188 pp.; illus. The Chemical Publishing Co., Easton, Pa., 1912. Price $2.00.

This work is, as its subtitle indicates, "A Treatise on Technical Drawing as Expressed Through the Medium of the Graphic Language." The table of contents shows the usual topics covered in a book of this kind, but the simple, methodical and concise manner in which the text is arranged should make it of great value to the beginner. The many illustrations, showing the most modern of the instruments used in drawing and blue-printing, stamp the book as up to date, while some valuable hints as to a first year course in drawing may be found in the Appendix.

T. H. H.

A Text-Book of Physics. By H. E. HURST and R. T. LATTEY, Oxford University. Cloth; 6x8 in.; illus. D. Van Nostrand Co., New York, 1912. Vol. I, Dynamics and Heat, 205 pp., $1.25. Vol. II, Sound and Light, 177 pp., $1.25. Vol. III, Magnetism and Electricity, 258 pp., $1.50.

This text-book presents the old familiar facts in more or less the old familiar way, instituted at the time when physics was known as natural philosophy. The idea of dividing the work into three volumes of handy size, however, is an innovaton which will be commended by students. The experimental method of presentation is followed throughout, which keeps one from forgetting the practical bearings of the subject. The explanations are often unnecessarily wordy, and many of the illustrations could be of much smaller size without losing clearness. In a few instances, topics seem to be misplaced; specific gravity, for example, is only casually connected with hydrostatics. Under light, the study of spectroscopy overlooks the effects of interference, and the use of gratings to produce spectra.

An important feature of the books, to British students, is the inclusion of a wide variety of questions and problems, at the ends of their appropriate chapters, selected from actual examinations given at Oxford, Cambridge, the Army school, and elsewhere, though the necessity for indicating where and when each question was asked is not apparent.

E. K. J.

ANNUAL MEETING OF THE ALUMNI ASSOCIATION

The last annual meeting was held in the rooms of the Aldine Club, New York City, on the evening of April 24, 1913. Arrangements had been made for the subsequent entertainment of a joint meeting with the Alumni Association of Columbia College.

The meeting was called to order at 8:30 o'clock; President F. M. Simonds in the chair.

1. On motion, the minutes of the meeting of April 26, 1912, were adopted as printed in the QUARTERLY, of Nov., 1912.

2. President Simonds, as Chairman of the Board of Managers, reported that the chief business coming before the Board was the matter of a re-apportionment of the income of the Association. That the matter of a continuance of the SCHOOL OF MINES QUARTERLY was duly considered, and, in view of the letter ballot, the Board of Managers had decided to continue the QUARTERLY.

President Simonds also stated that he had been in communication with the Secretary of the Alumni Council with a view of having the *Alumni News* furnished to members of the Association in lieu of the QUARTERLY. He reported that the News could not be furnished to members at a reduced rate that would make its substitution for the QUARTERLY desirable.

After some discussion the following motion was placed before the meeting, and carried:

Resolved, That it be recommended that the dues of the Association be increased to $3.50 per annum.

3. On motion of Mr. Moran it was ordered that the recommendation of the Board of Editors of the SCHOOL OF MINES QUARTERLY, that for the current year the Alumni Association contribute $1.00 per member instead of $1.50 per member in support of the QUARTERLY, be accepted.

4. The Treasurer submitted the following report, which, on motion, was accepted:

Treasurer's Report.

Receipts:	
Balance reported April 26, 1912	$1336.33
Dues received from Secretary, 1912-13	2861.63
Sale of School of Mines pins	374.50
For expenses of collation	72.00
Reimbursement for telegram	2.00
Interest on deposits to April 1, 1913	14.78
Total receipts	$4661.24
Expenses:	
Alumni Council	$1112.20
School of Mines Quarterly	1178.12
Typewriting and clerical work	298.45
Printing and postage	1300.93
Columbia University	2.55
R. E. Mayer, office expenses	22.05
Tiffany & Co., (badges)	378.00
Total expenses	$4292.30
Balance on hand April 22, 1913	$ 368.94
	$4661.24

On deposit in Irving Savings Institution	$ 737.01
Interest to date	27.88
Balance on deposit	$ 764.89

5. The Secretary presented the following report as to membership:

Report of Secretary.

Members, April 26, 1912		1268
Class of 1912 joining		79
Other classes joining		10
Resignations	12	
Deceased	7	
	19	1357
		19
Total membership, April 24, 1913		1338

Classification of Members.

Honorary members	8
Active members	1293
Associate members	37
Total membership	1338

6. Mr. Judd on behalf of the Board of Editors of the SCHOOL OF MINES QUARTERLY submitted the following report:

Report of School of Mines Quarterly Editors.

The QUARTERLY owes its continuance during the current year to three facts: First, that a majority of those who voted the ballot issued last June were in favor of maintaining its publication even at the expense of an increase in annual dues; Second, that the Board of Managers has taken no final action to abandon it; Third, that analysis of its financial status seems to warrant the hope that the QUARTERLY can be issued on a reduced stipend from the Association. A full discussion of these matters was published in the issue of November, 1912.

The last four issues of the QUARTERLY contained a total of 397 pages, allotted to subjects in the following proportions:

	Pages	Percent.
Mining	76	19
Mechanical Engineering	77	19
Civil Engineering	46	12
Electrical Engineering	17	4.5
Chemistry	18	4.5
Economic Geology	18	4.5
Mineralogy	11	3
Metallurgy	8	2
General	6	1.5
Chemical and Metallurgical Abstracts	30	7.5
Book Reviews	22	5.5
University Notes and Reports	38	9.5
Alumni Notes	30	7.5
	397	100.0

In regard to the technical matter, the apparent predominance of some subjects was not due to deliberate choice of the editors, but to

the nature of the material that came to us. The editors have, however, exercised their judgment in expanding the news features of the magazine. We trust that the members of the Association have noted with pleasure the increased amount of space devoted to Alumni Notes, and we hope that they also enjoy the news of events at the University.

Analyzing the contents of the last four issues as to their origin and authorship, we find that 50 percent. of the material was written by members of the Board of Editors or of the University Faculty; 16 percent. consisted of students' theses submitted to the Board by members of the Faculty; 18 percent. came from authors having no connection with Columbia, this material consisting principally of lectures delivered at the University; while only 16 percent. was written by members of this Association not connected with the University or Board of Editors. In previous years the proportion of material from the last mentioned source has been somewhat larger.

The QUARTERLY belongs to the Alumni, and it has not been by intention nor desire of the editors that it has tended, during the past year, to become more nearly a University publication. The editors feel that perhaps the members of this Association do not appreciate the value of the opportunity they possess as absolute owners of a publication in which they can set their accomplishments before the world in an effective yet perfectly legitimate manner.

Financial Statement of School of Mines Quarterly.

November 1, 1912, to April 24, 1913.

	Expenditures *	Receipts
Balance, Nov. 1, 1912		$ 949.33
Received from Alumni Association		699.60
Received from advertisements		427.25
Received from subscriptions and back numbers		130.05
Printing and mailing	$ 723.09	
Editorial services	200.00	
Engraving	145.19	
Addressing	29.74	
Telephone	11.75	
Printing of wrappers and envelopes	14.04	
Petty cash	8.25	
Clerical services	20.00	
Drafting	4.00	
Expressage	2.25	
Photography	1.75	
Postage (stamps received in payment)	.50	
Notary's fee	.50	
	$1143.36	
Balance in bank	1062.87	
	$2206.23	$2206.23

* This is exclusive of the bills for printing and editorial services for April, which are due.

7. The announcement of the election of Officers and Managers was made as follows:

President — Benjamin B. Lawrence.
Vice-President — Robert Van A. Norris.
Treasurer — John Sheafe Douglas.
Secretary — Ralph E. Mayer.
Managers — Walter M. Meserole, Francis D. Dodge, David M. Myers, George E. Hutchinson.

8. Mr. Theodore Tonnele presented the following resolution which, on motion, was unanimously carried:

Whereas, the graduates of the School of Mines, of Columbia College anticipate celebrating in May, 1913, the semi-centennial anniversary of the founding of that School; and

Whereas, the School of Mines as originally founded attained a reputation, not only national but international; and

Whereas, the Trustees of Columbia University some years heretofore, in their wisdom, thought best to substitute for the title, "School of Mines," the title "School of Mines, Engineering and Chemistry," now therefore be it

Resolved, that we, the graduates of the School of Mines, in view of the approaching anniversary, do hereby petition the Trustees to restore the original name of the School of Mines as a fitting tribute to the alumni of that School, who in the past have done credit to the School, its founders, and Columbia.

The above resolution was seconded by Theodore Tonnele, Wm. Elliott, A. Mc C. Parker, H. Garlichs, C. A. Meissner, Edward E. Sage, William W. Share.

9. On motion of Professor Walker the following resolution was adopted:

Resolved, that if the dues of the Association, on submission of the question to the membership, should not be increased to $3.50 per member, the question as to the continuance of the SCHOOL OF MINES QUARTERLY be referred to the Board of Managers with power.

10. At this point the meeting adjourned to the Assembly Hall for a social reunion and collation.

R. E. MAYER,
Secretary.

UNIVERSITY NOTES.

The Three-Year Course.— Details have now been practically all adopted for carrying into effect the decision of the Trustees to make the Schools of Mines, Engineering and Chemistry a post-graduate institution. To enter the School of Mines, on or after September, 1914, a candidate must have obtained 124 points in Columbia College, or an equivalent training in some other accredited college. Thus, while a bachelor's degree is not strictly a prerequisite for admission, the requirements are rigidly defined, and are actually more rigorous than in most graduate schools. Having been admitted under these conditions, a student, under the new arrangement, can complete the requirements for the engineer's degree in three years.

At the same time, Columbia College has rearranged its curriculum to permit a reasonably diligent student to obtain the required 124 points in three years, thus providing the mis-called "six-year" course. Of the required 124 points, 112 are compulsory, and 12 are optional; on the completion of this course, the College will give the degree of B.S. Entrance requirements to the College remain as before, except that trigonometry and solid geometry will be prescribed instead of optional.

THE COLLEGE COURSE.

FIRST YEAR.

First Term.	Points.	*Second Term.*	Points.
Advanced algebra	3	Anal. Geometry	3
English	3	English	3
Philosophy	3	Philosophy	3
Modern Language	5	Modern Language	3
Shopwork, 1 aft	1	Chemistry, General	5
Physical Education	1	Shopwork, 1 aft	1
	16	Physical Education	1
			19

SECOND YEAR.

Calculus	4	Calculus	4
Chemistry, General	5	Qualitative Analysis	5
English	3	Physics	6
History	3	History	3
Drafting, 2 afts	2	Drafting, 2 afts	2
Descriptive Geometry	3		
	20		20

THIRD YEAR.

Calculus	4	Surveying, Theory	2
Political Science	3	Political Science	3
Qualitative Analysis	5	Mineralogy	3
Physics	7.5	Physics	7.5
	19.5	Mechanics	2
			17.5

COURSE IN MINING ENGINEERING.

First Year.

First Term.	Hours.	Afts.	*Second Term.*	Hours.	Afts.
Physical Laboratory	0	1	Quantitative Analysis	2	4
Mechanics	3	0	Mechanics	3	0
Industrial Chemistry	3	0	Industrial Chemistry	3	0
Elements of Electrical Engineering	2	0	Electrical Machinery	2	0
Power Machinery	2	1	Power Machinery	2	0
General Geology	3	1	General Geology	3	0
Mineralogy	4	2	Railroad Surveying Theory	2	1
	17	5		17	5

Second Year.

Resistance of Materials	5	2	Graphic Statics	1	1
Assaying	2	3	Electrical Distribution	2	0
Economic Geology	3	0	Direct Current Laboratory	1	1
Engineering Thermodynamics	2	0	Economic Geology	3	0
Excavation and Tunneling	3	0	Engineering Thermodynamics	2	0
Mine Construction	1	0	Mechanical Laboratory	1	1
Sanitation and Hygiene	2	0	Petrography and Optical Mineralogy	0	2
	18	5	Boring and Shaft Sinking	2	0
			Methods of Mining	3	0
			Mill Construction	1	0
				16	5

Third Year.

Alternating Current Laboratory	1	1	Hydraulic Laboratory	0	1
Introduction to Metallurgy and Metallurgy of Copper	3	0	Gas Power	2	0
Electrometallurgy & Iron and Steel	2	0	Geological Surveys	2	0
Hydraulics	2	0	Metallurgy of Gold, Silver, etc.	3	0
Mine Plant	3	0	Metallurgical Laboratory	0	½
Design of Mine Plant	0	4	Mine Administration and Accounts	2	0
Ore Dressing	4	0	Mine Engineering	3	0
Steam Power Machinery	3	0	Mine Plant	3	0
	18	5	Mining Thesis	0	2½
Petrography (Elective)	2	1	Ore Dressing Laboratory	0	1
			Mining Law	2	0
				17	5½
			Palæontology (Elective)	2	1

COURSE IN CIVIL ENGINEERING.

FIRST YEAR.

First Term.	Hours.	Afts.	*Second Term.*	Hours.	Afts.
Physical Laboratory	0	1	Advanced Heat	3	0
Mechanics	3	0	Mechanics	3	0
Industrial Chemistry	3	0	Industrial Chemistry	3	0
Power Machinery	2	1	Power Machinery	2	0
Elements of Electrical Engineering	2	0	Electrical Machinery	2	0
Geodesy	2	0	Geodesy	1	1
Botany—Timber Growth	1	1	Engineering Chemistry	1	2
General Geology	3	1	Physiographic and Applied Geology	2	1
Metallurgy—Iron and Steel	2	0	Highway Engr. and Earthwork Calculation	1	½
	18	4		18	4½

SECOND YEAR.

Railroad Surveying	2	1	Masonry Structures	3	2
Resistance of Materials (Theory, Designs and Tests)	5	2	Railroad Surveying	3	1
Theory of Trusses	2	1	Sanitary Treatment Water Supply and Sewerage	3	0
Engineering Thermodynamics	2	0	Graphic Statics	2	1
Kinematics and Machine Design	3	1	Engineering Thermodynamics	2	0
Excavation, Tunneling, Boring and Shaft Sinking	2	0	Direct Current Laboratory	1	1
			Hydraulics	4	0
	16	5		18	5

THIRD YEAR.

Foundations	2	0	Business Law	2	0
Bridges, Roofs and Buildings	2	2	Bridges, Roofs and Buildings	2	0
Concrete Steel Construction	2	0	Alternating Current Laboratory	1	1
Railroad Engineering	3	1	Railroad Engineering	3	1
Electrical Distribution	2	0	Electric Railways	2	0
Water Supply and Irrigation	2	0	Design & Construction of Sewers, River & Harbor Improvements	2	0
Hydraulic Laboratory	0	1	Hydraulic Turbines	3	0
Mechanical Laboratory	1	1	Thesis	2	3
Thesis	3	0			
	17	5		17	5

COURSE IN METALLURGICAL ENGINEERING.

FIRST YEAR.

First Term.	Hours.	Afts.	*Second Term.*	Hours.	Afts.
Physical Laboratory	0	1	Electrical Machinery	2	0
Mechanics	3	0	Mechanics	3	0
Industrial Chemistry	3	0	Industrial Chemistry	3	0
Elements of Elect. Eng.	2	0	Railroad Surveying Theory	2	1
Power Machinery	2	1	Power Machinery	2	0
General Geology	3	1	General Geology	3	0
Mineralogy	4	2	Quantitative Analysis	2	4
	17	5		17	5

SECOND YEAR.

Resistance of Materials	5	2	Graphic Statics	1	1
Assaying	2	3	Direct Current Laboratory	1	1
Economic Geology	3	0	Economic Geology	3	0
Engineering Thermodynamics	2	0	Engineering Thermodynamics	2	0
Introduction to Metallurgy	1	0	Metallurgy of Lead, Silver, Gold and Zinc	3	0
Metallurgy of Iron and Steel	1	0	Electrical Distribution	2	0
Metallurgy of Copper	2	0	Mechanical Laboratory	1	1
Sanitation and Hygiene	2	0	Methods of Mining	3	0
			Optical Mineralogy	0	2
	18	5	Business Law	2	0
				18	5

THIRD YEAR.

Physical Chemistry	3	0	Mine Administration and Accounts	2	0
Alternating Current Laboratory	1	1	Gas Engines and Producers	2	1
Steam Power Machinery	3	0	Advanced Metallurgical Courses	4	0
Electrometallurgy	1	0	Metallurgical Laboratory	0	1
Constitution of Alloys	2	0	Mill Construction	1	0
Metallurgical Laboratory	0	4	Ore Dressing	0	1
Mine Construction	1	0	Mining Law	2	0
Ore Dressing	4	0	Hydraulic Laboratory	0	1
Hydraulics	2	0	Metallurgical Conferences	1	1
	17	5		12	5

Three-year courses in Chemistry, Chemical Engineering, Sanitary Engineering, Electrical Engineering and Mechanical Engineering, have been worked out along similar lines, but are not introduced here for lack of space. Their full details are printed in the forthcoming announcement of the Schools of Engineering, which will be ready for distribution early in the Summer of 1913, and may be obtained by application to the Secretary of the University.

Mining.—During April, R. V. Norris, E.M., 1885, consulting engineer of the D., L. & W. Coal Co., Wilkesbarre, Pa., delivered a series of six lectures on the following subjects: Mine transportation;

shaft sinking; and hoisting; preparation of anthracite; storage of anthracite; mine accidents; mine fires. Mr. Norris has had many years of intimate and varied experience with these matters, and his lectures are very highly esteemed by all who hear them. The Department provided printed syllabi, to relieve the strain of note-taking, and the lectures were further illustrated by charts and photographs.

Tau Beta Pi.—The following members of the Junior class (1914) were elected members of this honorary engineering society in March: John Cornelissen, H. W. Elsasser, Sidney Fisher, W. W. Havens, W. J. Krefeld, A. C. Nolte, A. E. Peterson, C. B. Sadtler, F. B. Schmidt, and Jane-shi T. E. Sen.

Mechanical Engineering Society.—On the evening of April 10, this organization held a banquet at Murray's, at which 55 members were present. Professors Jacoby and Rautenstrauch gave addresses, and Professor Piggott entertained at the piano. The meeting was highly enjoyed, and will be repeated next year.

On the evening of April 24 T. F. Githens described the process of beer brewing, and W. L. H. Doyle spoke on shop work in the plant of the Pierce Motor Co. After the meeting a smoker was held in the Commons.

The class in mechanical engineering took a trip to Bethlehem, Pa., during the Easter holidays, to inspect the works of the Carnegie Steel Co., under the direction of Professor Steffel.

Senior Mining Society.—Notice has been given that this society withdraws from among the recognized organizations of Columbia University, to take effect June 11, 1913.

Sigma Xi.— The ceremony of initiating the newly elected members, whose names appeared in our April issue, was held at the University on the evening of April 10, and was attended with the usual pomp and solemnity. At the banquet, which followed the initiation, Professor Jacoby served as toast-master, and addresses were made by Prof. E. L. Nichols, of Cornell, Prof. A. L. Dean, of Yale, Professors Fiske and Whitaker, of Columbia, and G. D. Fish of the graduating class in civil engineering. The occasion was highly enjoyed by the 73 members and guests present. On the evening of May 8, Prof. C. J. Keyser, of the Department of Mathematics, delivered an address on "The Figure and the Dimensions of the Universe of Space." The Columbia chapter of Phi Beta Kappa was invited to be present at this meeting.

Bust of Prof. Thomas Egleston.—The class of 1883, Mines, has contributed funds for a proper setting of the bronze bust of Prof. Egleston, and the work was completed in May. Thinking that the nature of the gift was not such as to warrant a formal presentation on Commencement Day, the following letter was sent to the President by the class committee:—

Nicholas Murray Butler, President Columbia University.

DEAR DR. BUTLER: Since the completion of the School of Mines building

the bronze bust of Professor Thomas Egleston has been standing on a temporary, wooden support in the hall of this building. The class of 1883, Mines, when considering the making of a gift to the University to commemorate the thirtieth anniversary of its graduation, at one of its meetings some time ago, expressed a desire to provide a suitable setting and base for this bust. After consultation with Dean Goetze and the University architects, an acceptable design was decided on and the work is now completed.

The action taken was the result of a unanimous vote of the members of the class, and is an expression of the esteem with which they remember one of the founders of the School of Mines. From Professor Egleston came the carefully studied plan and organization which resulted in a new educational departure in this country; to his energy and enthusiasm was due in large measure the success attained by the School of Mines, from its earliest days, nearly fifty years ago.

Professor Egleston was in all things a man of high ideals, an indefatigable worker and most conscientious teacher. The class of 1883 honor his memory, and are glad of this opportunity to record their appreciation of his great services to the School of Mines and to the University.

The committee representing the class in this matter does not deem it advisable to make a formal presentation on Commencement Day, and begs that, on behalf of the University, you will accept this modest gift from us without further formalities.

Respectfully,

ROBERT PEELE,
GEORGES RENAULT,
ARTHUR L. WALKER.

May 15, 1913.

FACULTY NOTES.

It was announced at a recent meeting of the Board of Trustees of Princeton University that Professor Alexander Smith, at present head of the Department of Chemistry at Columbia, has accepted a position as Professor in that institution, for the year 1914-1915. Professor Smith has been a member of the Faculty of Chemistry at the University for two years, coming here from the University of Chicago to succeed Professor C. F. Chandler, who was made an emeritus Professor at that time.

Professor Walter Rautenstrauch delivered a lecture on the subject of "Mechanical Engineering" at the U. S. Naval Academy, Annapolis, Md., on Tuesday, April 15. On Wednesday evening, April 16, he was the guest of the Columbia Alumni of Philadelphia at the Engineers' Club.

Professor W. I. Slichter, of the Department of Electrical Engineering, delivered a lecture at the U. S. Naval Academy at Annapolis, on April 22, on the subject of the "Application of Electrical Engineering to Marine Work." This was one of a course of lectures given to the naval engineers in the post-graduate course.

Arthur H. Blanchard, M. Am. Soc. C. E., Professor of Highway Engineering, Columbia University, on April 10 delivered an illustrated address entitled "Modern Bituminous Pavements for Municipalities" before the Board of Trade of Elizabeth, N. J.

Edward D. Thurston, Instructor in Mechanical Engineering, will attend the joint meeting of the American Society of Mechanical Engineers and the Verein des Deutsches Inginieure, which will be held in Germany in June. In connection with the meeting, a trip through the manufacturing centers of Germany has been arranged lasting about two weeks.

ALUMNI NOTES.

1875. J. S. C. Wells, Ph.D., left New York on March 18, for a professional trip to Santo Domingo. He expects to return in July.

1883. J. J. MacTeague, E.M., mine and ranch owner of San Juan de Guadalupe, Symon, Durango, Mexico, called at the School of Mines, March 11, 1913.

1895. Henry W. Durham, C.E., Chief Engineer in charge of Highways of the Borough of Manhattan, is the responsible author of a little pocket-book "Instructions to Inspectors of Street Paving," recently issued by the office of the Borough President.

1895. B. B. Gottsberger, C.E., General Manager of the Miami Copper Co., Miami, Ariz., is recovering from a severe illness in California. His place is being taken temporarily by J. Parke Channing, '83, President of the company.

1895. A class reunion, attended by 39 College and Engineering graduates, was held at the Union Square Hotel, on the evening of April 2. Among the engineers present were: Durham, Emanuel, Goetze, Huntoon, McKinlay, Perrin and Post. In preparation for the 25th anniversary, various committees were appointed. Resolutions were passed to provide a class fund by subscriptions of $1 per year; the treasurer is E. B. Sturgis, Pleasantville, N. Y. The next meeting will be held on Commencement day.

1895. L. D. Huntoon, E.M., 115 Broadway, New York, is eastern representative of the Stearns-Roger Manufacturing Co., of Denver. His professional work will be continued as in the past.

1895-99. At a dinner held at the Buckingham Hotel, New York, on April 11, details were completed for the organization of "The Last of the Forty-niners," the name having reference to the fact that these classes were the last to attend the University on the old down-town site. Prof. W. I. Slichter, of the University, is vice-president.

1899. H. E. Crawford, E.M., manager of the Cinco Minas Co., states that the company's post-office address has been changed from Hostotipaquillo to Magdalena, Jalisco, Mexico.

1901. Lester G. Wilson, Mech. E., was recently elected to the board of directors to the Norfolk Chamber of Commerce. He already held a similar position with the Jas. G. Wilson Manufacturing Co., and the Williamson Submarine Corporation.

1901. David M. Meyers, Mech. E., has just completed the design and erection of a 1000-h.p. boiler plant for an Albany factory, and is now making detailed study of plants in Brooklyn and Newark. An article of his on "Safe Piping for Boiler Plants" appeared in *Power*, Dec. 10, 1912, and another series on "Economic Combustion of Waste Fuels" is now running in the *Engineering Magazine*.

1901. A. L. J. Queneau, E.M., consulting engineer, of Philadelphia, is at Jemeppe sur Meuse, Belgium, where he expects to remain for some time longer.

1902. Henry F. Haviland, E.E., has formed a new concern for the manufacture and sale of electrical apparatus, under the name of Walker Bros. & Haviland, 38 W. 32d St., New York.

1902. T. T. Read, E.M., has come from San Francisco and has opened an editorial office of the *Mining and Scientific Press* in Room 1310, Woolworth Bldg., New York. He was recently elected Secretary of the New York Section of the A. I. M. E.

1903. Arthur M. Wolff, C.E., is with the General Kompolite Co., 516 Fifth Ave., New York.

1903. S. F. Shaw, E.M., superintendent of the Tiro General mine, Charcas, S. L. P., Mex., was in New York in May.

1904. Daniel R. Bacon, E.E., and C.D., Trubenbach, C.E., '05, have formed a concern for the designing of power and manufacturing plants, with office at 30 Church St., New York.

1904. Milton H. Fies, E.M., is Vice-President and Secretary of the Maryland Coal and Coke Co., with office at Jasper, Ala.

1905. F. P. Bayless, E.M., who for some years has been located in the vicinity of Trinidad, Colo., has been appointed Asst. Gen. Mgr. of the New River Collieries, and will shortly have his office at Eccles, W. Va.

1905. A. H. Case, E.M., formerly Manager of the Tennessee Copper Co., at Copperhill, Tenn., has resigned that position and has become consulting engineer for the Lewisohn Brothers, New York City.

1907. Richard S. Burdette, E.M., is president of a photographic supply company and partner in an assay and analytical laboratory at Guadalajara, Jalisco, Mex. Was married, Aug. 10, 1912, to Francisca Josefina Fuchs, of that city. Address: calle San Francisco 158.

1908. H. F. Davis, E.M., has gone from Keeler, Cal., to Dale, Cal., where he is engaged in gold mining.

1908. A. W. Newberry, Met. E., is now with the Canadian Copper Co., at Copper Cliff, Ontario.

1909. Herbert S. Kohlberg, E.M., formerly at the Pilares mine of the Moctezuma Copper Co., Nacozari, Mex., is now assistant superintendent of the Kennedy mine of the East Canada Smelting Co., at Weedon, Quebec. He visited New York in May.

1909. M. M. Thompson, E.M., is now engaged in the exploration of oil fields for the Standrad Oil Co., in the island of Trinidad.

1909. H. W. Walter, Met. E., is superintendent of the Camden Works of the International Nickel Co. Address: 69 Franklin Ave., New Brighton, Staten Island, N. Y.

1909. Freeman W. Kennedy, E.E., left New York in April, to become a sales engineer in the electrical division of the General Motors Truck Co., 753 Boylston St., Boston, Mass. He had previously been connected in Detroit with the same company.

1909. D. B. Steinman, C.E., is Associate Professor of Civil Engineering at the University of Idaho, Moscow, Idaho, and has charge of the design and construction of the University's grounds. He is the author of "Suspension Bridges and Cantilevers" (D. Van Nostrand Co.) and of a translation of Melan's "Theory of Arches and Suspension Bridges" (M. C. Clark Pub. Co.) He presented a paper on "Bridges" at the Spokane Congress of Engineering and Scientific Societies in April, which has been reprinted by several engineering papers.

1910. L. A. Parsons, E.M., is mine engineer with the Dome Mines Co., South Porcupine, Ontario.

1910. John I. Kane, E.M., has been temporarily transferred from the Charcas to the Angangueo (Michoacan) plant of the A. S. & R. Co., in Mexico. Kane was with S. F. Shaw, '03, during the recent excitement at Charcas, when, by display of great fortitude and bravery, they succeeded in rescuing the women and children of the camp from besieging revolutionists.

1910. H. L. Carr, E.M., returned in May from an extended trip through Colombia in exploration of gold placer deposits, which he reports was successful. He expects to return to another part of the same country in June.

1910. John D. Tallant, E.M., formerly of Goldfield, Nev., is now with the Braden Copper Co., Rancagua, Chile.

1910. William H. Shearman, E.M., who has been associated with a number of other Columbia men in the exploration of oil shales for the New Brunswick Shale Development, Ltd., at Turtle Creek, N. B., returned to New York in May.

1911. Robert L. Morrow, Mech. E., is serving as liability inspector with the Fidelity and Casualty Co., 92 Liberty St., New York. He recently returned from an extended trip in the Northwest, where he was inspecting mainly the sawmills and other hazardous enterprises.

1911. Frederick S. Frambach, Mech. E., has lately been made superintendent of the mechanical department of the Webb Wire Works, New Brunswick, N. J. Address 100 Bayard St.

1911. Clark G. Mitchell, formerly engineer with the Brittania Mining and Smelting Co., is now superintendent of the Isabella mines, Cripple Creek, Colo.

1911. R. W. Briggs, C.E., Professor of Engineering in Trinity College, Durham, N. C., is highway engineer for Granville county; he was recently elected a member of the North Carolina Academy of Science.

1912. N. R. Sethna, E.M., is assistant mine inspector at the iron ore mines of the Tennessee C. I. & R. Co., at Birmingham, Ala. Address: 1830 Arlington Ave., Bessemer, Ala.

1912. B. C. Staiger, E.M., is at Live Oak Camp, Miami, Ariz.

1912. The Chemists and Chemical Engineers of this class held a reunion at Mouquin's, Saturday evening, May 3. Those present were: Pfeiffer, Struthers, Maas, Read, Norton, Ormont, Rohn, Simon, Seil, Thorn, Lamb, Hochberger, Huttlinger, Bates and Thomas.

PROF. WILLIAM HALLOCK.

Prof. William Hallock, of Columbia University, died on Tuesday, May 20, at the Homœopathic Hospital, in Providence, R. I. He was born in Milton, N. Y., August 14, 1857, the son of Isaac S. and Phœbe H. Hallock; was graduated from Columbia College with the class of 1879, and then went to Germany, where he studied in the University of Wurzburg, taking the Ph.D. degree in 1881, and acting the following year as an assistant in the physical laboratory there. For the next nine years he was physicist for the United States Geological Survey in Washington, and part of that time he spent as professor of physics at the Corcoran Scientific School. From 1889 to 1892 he was professor of chemistry and toxicology in the National College of Pharmacy, and in the year following his retirement from the Geological Survey, 1891-2, he was assistant in charge of the astro-physical laboratories of the Smithsonian Institute.

While connected with the Geological Survey, he conducted the investigation of subterranean temperatures in the famous dry well at Wheeling—the second in depth in the world—where the drill went down to 4,500 feet below the surface of the earth. His experiments were described in a paper read last year before the American Association for the Advancement of Science. He was also for three years at work in the Yellowstone Cañon, investigating the phenomena of the hot springs and geysers there, and comparing results with those obtained by Professor Bunsen in Iceland. In collaboration with Prof. Carl Barns, of the Geological Survey, he worked for some time at New Haven, studying methods of measurement of high temperatures. Among the other topics to which he gave his attention were the effects of pressure on powdered materials and the thermal expansion of rocks.

He returned to Columbia in 1892 as an associate professor in physics, and in 1902 was made professor. Four years later he was appointed dean of the faculty of pure science, and held that office until all the graduate faculties at Columbia were merged, in 1909. While at Columbia his researches were mainly in acoustics.

Professor Hallock was a member of the American Philosophical Society, the American Physical Society, the American Association for the Development of Science, the New York Yacht and other clubs. He is survived by a wife and two daughters, Mrs. Robert Corté and Miss Josephine Hallock.

ESTABLISHED 1851

EIMER & AMEND

205-211 Third Ave.,
New York City

HEADQUARTERS FOR

Chemicals, Chemical Apparatus and Assay Supplies

Mine Laboratory Supplies

Platinum Ware—best hammered.

Pyrometers, Optical, Thermo-Electric

Electric Furnaces for Laboratory Purposes

Balances and Weights of every Description

Chemicals, Chemically pure and Technical

COMPLETE LABORATORY
AND
PROSPECTING EQUIPMENT

First Quality Supplies Only

Prompt Service

SERIAL

The School of Mines Quarterly

vol. 34, 1912-13

DATE DUE	BORROWER'S NAME